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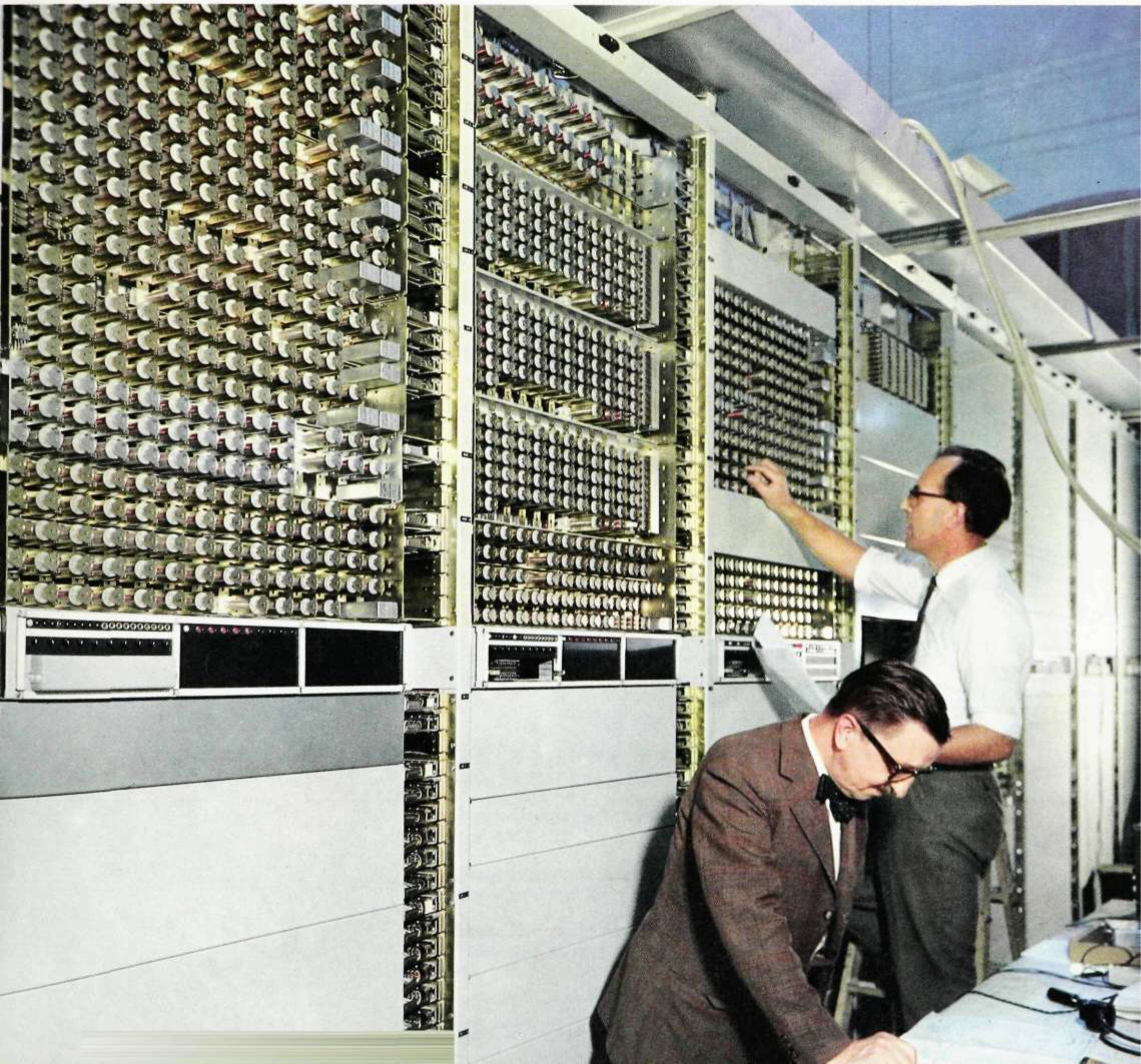

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On cover: Tests of telex exchange in Spain

Signalling in L M Ericsson Telex System

E. STRINDLUND & C. PAULSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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Signalling occurs in a telex network in conjunction with the setting up and clearing of connections between exchanges and takes place, respectively, before and after the transmission of information between the connected subscribers. An account is given below of the signalling principles used in L M Ericsson's telex system within the framework of the CCITT recommendations for establishing, supervising, clearing and charging national, international and intercontinental telex connections. The signalling used in national networks may be characterized as CCITT Type B with keyboard selection and printed service signals. International and intercontinental exchanges have equ.pment for Type A, Type B, Type C Table II and U 20 signalling.

L M Ericsson Telex System

The system comprises the following types of exchanges:

- National terminal exchanges type *ARB 111*
- National transit exchanges type *ARM 201* and *ARM 503*
- International transit exchanges type *ARM 201*
- Intercontinental transit exchanges type *ARM 201*

Fig. 1 shows how a national network can be built up with these types of exchanges.

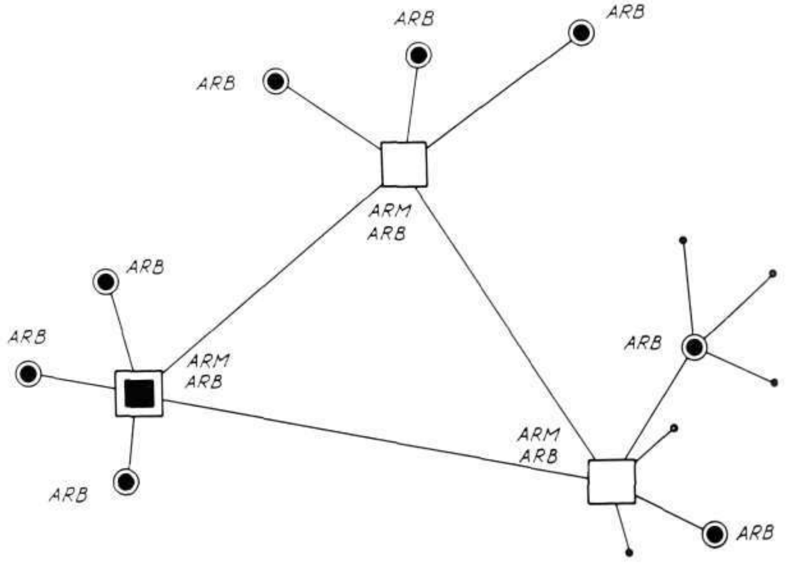

Fig. 1

Telex network

■ International transit exchange ARM + ARB 111

□ National transit exchange ARM 201 or ARM 503 + ARB 111

◉ Terminal exchange ARB 111

● Remote or local subscriber

No	↑	↓	CCITT No 2				
			1	2	3	4	5
1	–	A	●	●	○	○	○
2	?	B	●	○	○	●	●
3	:	C	○	●	●	●	○
4	✠	D	●	○	○	●	○
5	3	E	●	○	○	○	○
6		F	●	○	●	●	○
7		G	○	●	○	●	●
8		H	○	○	●	○	●
9	8	I	○	●	●	○	○
10	Ω	J	●	●	○	●	○
11	(	K	●	●	●	●	○
12	)	L	○	●	○	○	●
13	.	M	○	○	●	●	●
14	,	N	○	○	●	●	○
15	9	O	○	○	○	●	●
16	0	P	○	●	●	○	●
17	1	Q	●	●	●	○	●
18	4	R	○	●	○	●	○
19	'	S	●	○	●	○	○
20	5	T	○	○	○	○	●
21	7	U	●	●	●	○	○
22	=	V	○	●	●	●	●
23	2	W	●	●	○	○	●
24	/	X	●	○	●	●	●
25	6	Y	●	○	●	○	●
26	+	Z	●	○	○	○	●
27	<		○	○	○	●	○
28	≡		○	●	○	○	○
29	↓		●	●	●	●	●
30	↑		●	●	○	●	●
31	→		○	○	●	○	○
32			○	○	○	○	○

Fig. 2

International 5-unit Telegraph Alphabet No. 2

For single current	For double current
○ No current	○ Start polarity A
● Current	● Stop polarity Z

For meaning of symbols see fig. 3.

- ⊟ Hyphen
- ⊞ Answer-back tripping signal
- ⊡ Full-stop
- ⊞ Plus
- ⧀ Carriage return
- ≡ Line feed
- ↓ Letter shift
- ↑ Figures shift
- → Space

Fig. 3

Symbols used in fig. 2 and subsequent diagrams

The skeleton of the network consists of transit centres *ARM*, with which one or more terminal exchanges *ARB 111* are always integrated. The remaining terminal exchanges, in the number required, can be connected to the transit centres on VF telegraph channels.

Up to 15 classes of subscribers can be connected to *ARB 111*. Examples of such classes are ordinary telex subscribers, police, banks, news agencies, embassies, subscribers with Roman and subscribers with Arabic alphabet.

Every subscriber is given a corresponding classification marking which is signalled in the form of 1 out of 15 selected combinations from CCITT's Alphabet No. 2, which is shown in its entirety in fig. 2. The class signal is called *K* in subsequent signalling diagrams.

A country can be divided into a large number of tariff zones. To any one terminal exchange *ARB 111* it is possible to connect subscribers situated in up to 20 zones and base the tariffs on the geographical distance between the communicating *A* and *B* subscribers.

In accordance herewith every subscriber is given a tariff zone marking consisting of 1 of 20 telegraph characters also selected from Alphabet No. 2 and called *T* in the signal diagrams.

To achieve the greatest possible rapidity and reliability in switching, all information is signalled in telegraph code both between exchanges and from the calling subscriber to the exchange equipment.

The signalling principles that have been chosen are accordingly aimed at achieving the most efficient signalling possible within the framework of a telegraph speed of 50 bauds. One example of this is that, at the same time as the calling subscriber receives the printed proceed-to-select signal *GA* from the terminal exchange as a request to deliver selection information (either by automatic tape transmitter or manually), the exchange equipment sends the *T* och *K* information concerning the subscriber to the superior transit centre.

For further information reference should be made to Ericsson Review No. 2/1967.

An account will be given first of the signalling principles employed and thereafter, in the form of signalling diagrams, examples of signalling for different switching procedures.

General Technical Conditions for Telex Signalling

Automatic and manual telex systems use the same channel for transmission of information and signalling. The properties characterizing the transmission of information, therefore, will also affect the signalling principle. As, in telex systems, the transmission of information is done digitally at a speed of 50 bauds, the following types of signals will be used in telex signalling.

- ☐ Changes between two conditions, called by CCITT start and stop polarities. A condition must have a certain duration in order to be interpreted as a signal.
- ☐ Single pulses which, at a signalling speed of 50 bauds, must not be shorter than nominally 20 ms (according to definition of 50 bauds).
- ☐ Pulse trains composed of the aforesaid pulses, e.g. forming teleprinter signals in accordance with CCITT Alphabet No. 2 (see fig. 2).

On physical subscriber lines other signals may also occur, e.g. 1000 Hz signals for stepping of private meters at the subscribers' premises.

The signalling principles and signals are likewise affected by the exchange equipment in use. Register-controlled systems, for example, permit digital transmission between exchanges in the form of teleprinter signals and at a speed of 50 bauds, which implies a transmission speed of 6.7 digits per second.

Signals and Signalling Conditions Recommended by CCITT

CCITT has defined a number of signals and signalling conditions, of which the most important are listed below.

Free line condition. The circuit is free for traffic.

Calling signal. Transmitted on the forward signalling path.

Call-confirmation signal. Returned on the backward signalling path to indicate reception of calling signal.

Proceed-to-select signal. Returned on the backward signalling path to indicate that the distant terminal equipment is prepared to receive selection information.

Selection signals. Transmitted on the forward signalling path to indicate the number required.

Call-connected signal. Returned on the backward signalling path to indicate that the call has reached the *B* subscriber and that the latter is free.

Idle-circuit condition. An established connection ready for exchange of information.

Clearing signal. Transmitted on either signalling path.

Service signals. Returned on the backward signalling path, e.g. if the *B* subscriber is engaged.

Type *A* and Type *B* Signalling

According to the CCITT Blue Book, Volume VII, Recommendation *U 1*, the following signalling conditions are equivalent in Type *A* and Type *B* signalling.

Start polarity. The polarity of the start pulse in the International Telegraph Alphabet No. 2.

Stop polarity. Polarity of the stop pulse in the same alphabet.

Free line condition. Permanent start polarity on the forward and backward signalling paths.

Call. On the forward signalling path a reversal of polarity takes place to permanent stop polarity.

Idle-circuit condition. On an established connection a permanent stop polarity is sent on the forward and backward signalling paths.

Clearing signal. Consists of a reversal of polarity to permanent start polarity on either signalling path. The start polarity is interpreted by the exchange equipment as a clearing signal within 300–1000 ms.

Clear-confirmation signal. Consists of a reversion to start polarity on the other signalling path in response to a clearing signal. When a clearing signal has reached the receiving line relay set, a confirmation signal must be sent back in the other direction within 350–1500 ms after reception of the reversal of polarity. The minimum period will be increased to 400 ms in future systems.

The table below shows the signals recommended for use in subscriber-controlled fully automatic telex traffic which differ in the two types of signalling.

Signal	Type A	Type B
Call-confirmation	Permanent stop polarity	25 ms pulse of stop polarity (between 17.5 and 35 ms)
Proceed-to-select	40 ms (± 8 ms) pulse of start polarity	25 ms pulse of stop polarity (between 17.5 and 35 ms)
Selection	Teleprinter signals	Dial pulses or teleprinter signals
Call-connected	150 ms (± 11 ms) pulse of start polarity followed by stop polarity for at least 2 sec. and possibly teleprinter signals	Stop polarity for at least 2 sec.
Busy	Teleprinter signals followed by clearing signal	a. 200 ms pulse of stop polarity followed by start polarity for 1500 ms (tolerance ± 30 %)* b. 200 ms pulse of stop polarity (tolerance ± 30 %) followed by teleprinter signals and start polarity for 1500 ms (tolerance ± 20 %)*
Out-of-order, number changed and number unobtainable	Clearing signal normally preceded by teleprinter signals	a. Permanent start polarity** b. 200 ms pulse of stop polarity followed by start polarity for 1500 ms (tolerance ± 30 %)* c. 200 ms pulse of stop polarity (tolerance ± 30 %) followed by teleprinter signals and start polarity for 1500 ms (tolerance ± 20 %)*

* This sequence of signals may be repeated until a clearing signal is sent over the forward signalling path.

** The use of this signal should be avoided if possible.

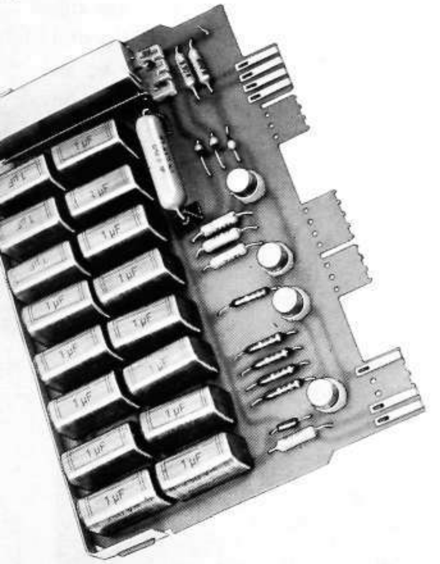

Fig. 4

Time circuit used, among other purposes, for determining the operate or release times of relays within the range 1-1000 sec.

Is used, for example, on repeater racks for checking the efficiency on radio channels with ARQ equipment and employing U 20 signalling.

U20 and Type *C* Signalling

In telex networks radio channels are often used over large distances. In order that these channels may operate reliably, a 7-unit alphabet is employed which provides 35 combinations, all of which have the ratio 3 : 4 between stop and start polarity pulses. Thirty-two combinations are used to represent the characters of the 5-unit alphabet and the remaining three have special significations. At the receiving end of a connection the signals are analysed and those not having the ratio 3 : 4 give rise to a request for signal repetition, whereupon an *RQ* signal is sent.

The *RQ* signal is one of the three aforementioned special signals. The two others are used to characterize the two polarity conditions, start and stop, and are called α and β signals.

During free line condition, for example, signals are sent continuously in both directions on an *ARQ* circuit. A call is signalled by substituting β signals for α signals in the forward direction.

The entire signalling procedure is defined in Recommendation *U 20* in the CCITT Blue Book, Volume VII, from which the name *U 20* signalling derives.

All intercontinental telex signalling on cable, satellite and radio circuits is now Type *A*, Type *B* or *U 20*.

In a new Recommendation *U 11*, CCITT has introduced a new signalling system called Type *C*. The recommendation is so recent, however, that it is still being revised (CCITT, JWP Study Groups I and X, Melbourne 1966), and it is difficult to predict the use to which Type *C* signalling may be put.

Signals in L M Ericsson Telex System

The signalling used in L M Ericsson's telex system may be characterised as CCITT Type *B* with keyboard selection and printed service signals. As a large number of telex exchanges in the world have Type *B* signalling, it was natural in the development of L M Ericsson's telex system to adopt Type *B*. As the use of registers, moreover, was obviously desirable, it was possible to introduce keyboard selection, which is preferable to dial selection owing to its greater rapidity. In conjunction with the introduction of keyboard selection it is also desirable to use printed service signals.

Signalling of Numerical Information by Register

The *A* subscriber sends the numerical information to the register at the transit centre. This register transmits the numerical information either to a register at another transit centre or to a code receiver at a terminal exchange, after which the first mentioned register leaves the circuit and the subsequent setting up of the connection is taken over by the next unit. This method of linkwise setting up of the connection is suitable on account of the small number of signals available for telex signalling. Backward signals of different kinds would unnecessarily complicate the equipment.

Digital transmission between registers and between register and code receiver is done with teleprinter signals in accordance with CCITT Alphabet No. 2. On interexchange circuits it is of course of great importance that the digital transmission is effected as quickly as possible, i.e. with teleprinter signals. This applies especially on expensive international and intercontinental circuits. As a large part of the telex traffic is international, there will be an increasing demand for the use of teleprinter signals for digital transmission on national circuits.

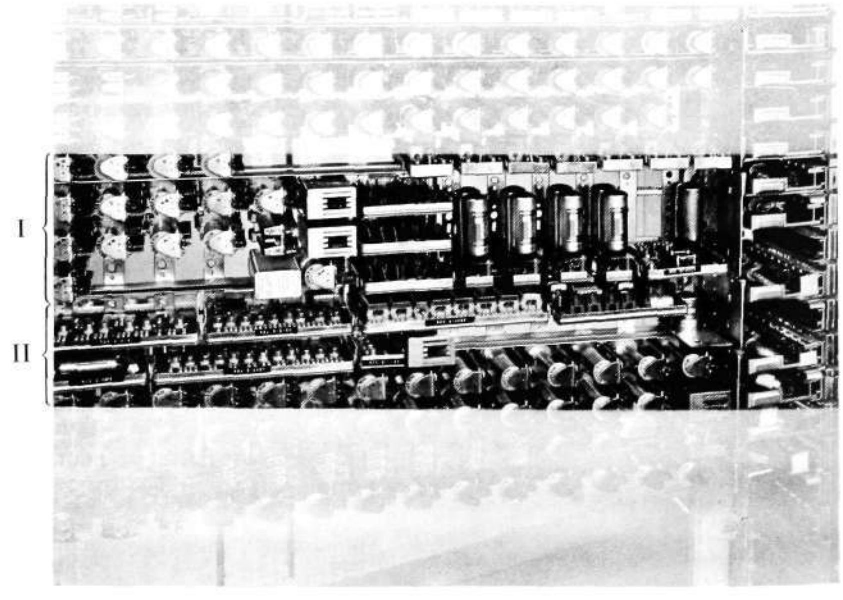

Fig. 5

I: Part of telegraph signalling generator which generates all 32 combinations of the 5-unit alphabet and forms service signals such as OCC, NA, NC etc.

II: Electronic telegraph signalling receiver for reception, for example, of subscriber's keyboard selection signals.

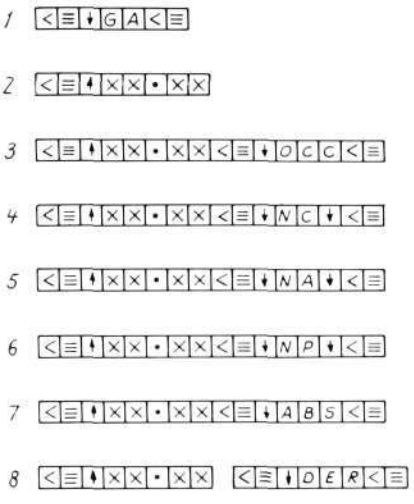

Fig. 6

Form and meaning of printed service signals.

Signal	A-subscriber reads
1 Proceed-to-select	GA
2 Time announcement	e.g. 09.11
3 Busy	09.11 OCC
4 No-circuit	09.11 NC
5 Connection not admitted	09.11 NA
6 Not a working line	09.11 NP
7 Office closed, e.g. for holidays	09.11 ABS
8 Out-of-order	09.11 DER

Keyboard Selection

In order to avoid receiving equipment both for teleprinter and dial signals in registers, among other reasons, it is advisable that the subscriber's selection information should be sent from the teleprinter keyboard. As mentioned above, the transmission of the selection information should be quicker than with dial selection, owing both to the telex subscriber's familiarity with the use of keyboards and to the fact that this procedure enables the subscriber to use his automatic tape transmitter also for sending the selection information. (This is convenient for the subscriber especially on international calls, which may involve a large number of digits.)

With keyboard selection it may happen that, between two digits, the telex operator keys another character than a digit. Instead of, in this case, sending *NP* (see below) to the *A* subscriber, which may cause confusion as the latter is presumably not aware of the error he has committed, other characters than digits are accepted but not registered by the register and the connection is established in the normal way when the necessary digits have been received. Before the subscriber starts numerical transmission he sends a "prepare for digits" signal which consists of Combination No. 30 (figure-shift) and which "opens" the register.

The possibility both of keyboard and dial selection was achieved through the fact that the register can be equipped with a special decadic receiver and through the use of classification (see below) for informing the register whether the subscriber uses keyboard or dial selection.

Printed Proceed-to-Select Signal

With the use of keyboard selection the teleprinter motor must start at an early stage. The sound of the starting of the motor might be used as a proceed-to-select signal. On the other hand silent electronic teleprinters may come into use within the not too distant future. It is also necessary that the teleprinter motor runs up to speed before the subscriber starts to send selection information. It is therefore advisable to give the subscriber a clear indication that he can start, which is done in the form of a teleprinter signal *GA* (go ahead), as the subscriber's attention is directed to the teleprinter after the motor has started, not to the control unit.

Printed Service Signals

Printed service signals in accordance with CCITT recommendations could be introduced as the teleprinter motor starts at an early stage in the setting up of the connection. Such signals give the *A* subscriber more detailed information concerning the reason for failure of a connection than a simple busy-and-congestion signal. Unnecessary renewed attempts at connection can thereby be avoided.

The service signals used are as follows:

OCC	Subscriber engaged
NC	No circuits, e.g. all trunks busy
NA	Connection not admitted
ABS	Subscriber absent or office closed
DER	Out of order
NP	Not a working line

Each service signal is preceeded by a time announcement, e.g. 09.11, as shown in fig. 6.

Automatic Tripping of B Subscriber's Answer-Back

As, with keyboard selection, the teleprinter motor starts early, this criterion cannot be used for informing the *A* subscriber that he is connected to the *B* subscriber. For the same reasons as above concerning the proceed-to-select signal, it is desirable that the call-connected signal should be printed on the subscriber's teleprinter. By automatically tripping the *B* subscriber's answer-back when the call is put through, a printed signal of this kind is obtained which also informs the *A* subscriber whether he has been connected to the correct *B* subscriber. In order that charging of the *A* subscriber shall not start until he has been informed of the identity of the *B* subscriber, a delay in starting can be arranged.

A time signal indicating hours and minutes is sent to the *A* and *B* subscribers immediately before the automatic tripping of the *B* subscriber's answer-back.

Signalling of Tariff Information

National calls are charged on subscribers' meters at the terminal exchange. Since the registers are located at the transit centre, the tariff to be applied for each individual connection should also be determined at the transit centre, namely by the *ARM* exchange route marker. Since no tariff pulses can be signalled on trunk circuits during an established connection, it is necessary, before the connection is established, to signal the tariff from the transit centre to the terminal exchange. Accordingly the tariff is signalled to the code receiver at the terminal exchange (see signalling diagram) from the register which receives the tariff information from the route marker.

The code receiver then sets up the tariff relays in the repeater. The signal between register and code receiver consists of a teleprinter signal and is denoted *Z*. For greater reliability in the transmission of the signal a 2-out-of-5 code has been used, i.e. the 10 telegraph signals among the 32 combinations have been chosen which have two start pulses and three stop pulses. The ratio of the number of start to stop pulses is then checked on reception in the code receiver.

15 Classes of Subscribers Can be Connected to the Terminal Exchange ARB

Classes in telex applications are used primarily to decide whether a connection between two subscribers is permitted or not. In L M Ericsson telex system the classes of the *A* and *B* subscribers are determined at the respective terminal exchanges. To decide whether the connection is permitted, therefore, it is necessary to transmit the *A* subscriber's class to the *B* subscriber's terminal exchange, which is done in conjunction with the setting up of the connection. The *A* subscriber's class is signalled by means of a teleprinter signal denoted *K* from the terminal exchange to the register in the transit centre for onward transmission to another register or code receiver. The transmission to the first register takes place before the subscriber has sent the selection information, so that it is possible to bar a special route or determine a special route and a special tariff in the transit centre on the basis of the received classification. Onward transmission of the classification to register or code receiver is done in conjunction with the transmission of the numerical information.

Tariff Zones

Owing to the large number of subscribers who may be situated at a large distance from the terminal exchange it has often been advisable, from the charging point of view, to distinguish between different groups of subscribers connected to the same terminal exchange. In this way a charging system can be arranged in which the tariff can be determined strictly according to the distance between the *A* and *B* subscribers. The subscribers connected to the terminal exchange can be divided into 20 groups. The subscribers within a group are given a special tariff zone marking. The tariff zone, like the subscriber class, is signalled before the subscriber's selection information from the terminal exchange to the transit centre and can therefore be used at the transit centre for determination of the tariff. The tariff zone (called *T* on the signalling diagram) is signalled by a teleprinter signal from the terminal exchange to the register in the transit centre in conjunction with the signalling of the subscriber class information.

Subscribers with Different Alphabet on the Same Terminal Exchange

The connection of subscribers with different alphabets (e.g. Roman and Arabic) is made possible by the use of classification. In order that both classes of subscribers may receive printed service signals, however, the system has two sets of telegraph signalling generators for service signals. Switching between them is done on the basis of the received class.

Head-on Collision

Early detection of head-on collision through the use of Type B signalling is made possible by the fact that the call and call-confirmation signals differ in form. Although the probability of head-on collision is small, especially within national networks, measures must be taken when such collision occurs. On a head-on collision on a circuit between two transit centres a reselection of line repeaters is made. On a head-on collision between a terminal exchange and a transit centre a reselection is made in the transit centre, while the call is passed through in the direction from the terminal exchange to the transit centre.

Retest Function

A call on a trunk circuit must be acknowledged by a call-confirmation signal. Should this signal not be returned owing to a line fault, for example, a

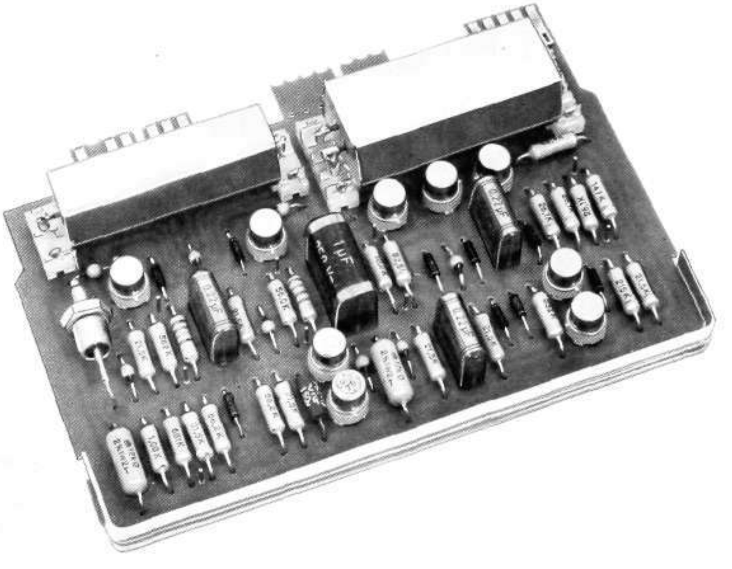

Fig. 7

Time supervision circuit for recognition of calling and clearing signals

register in *ARM* selects a new circuit on the route or on an alternative route. The repeater which did not receive a call-confirmation signal initiates a retest procedure consisting of transmission of the sequence 1 second stop polarity and 29 seconds start polarity. This continues until either a call-confirmation signal is received or until the maintenance personnel take action in response to an alarm, which is issued when the retest signalling has proceeded for about 3 minutes.

Prevention of Character Printing on Clearing of Call

With single current, unless special measures are taken, characters may sometimes be printed on the teleprinter of one subscriber in conjunction with the clearing of a call. If the *A* subscriber clears, characters will be printed on the *B* subscriber's teleprinter, and vice versa. To avoid this, a special signal is used on the subscriber line which receives a clearing signal (see signal diagram). The breaking of the subscriber's loop, which indicates clearing, is allowed to last for max. 150 ms, after which the idle circuit condition is restored. After the recognition time for the clearing signal, 400–600 ms, the polarity of the subscriber's line is reversed and the current returns to the free line value.

International and Intercontinental Signalling

In the introduction to Recommendation *U 1*, CCITT stipulates: "the outgoing country should conform to the signalling requirements of the incoming country." This is an important principle and has a great effect on the design of international and intercontinental telex exchanges.

The international telex exchange in Madrid, for example, must interwork with the following signalling systems for fully automatic subscriber-controlled international traffic to

☐ Spain, i.e. Spanish national network	Type *B* with keyboard selection, printed service signals and automatic tripping of Spanish *B* subscriber's answer-back.
☐ Austria, Denmark, Germany, Switzerland	Type *B* with dial selection but without printed service signals and without automatic tripping of *B* subscriber's answer-back in the respective countries, which is instead done from the Madrid centre.
☐ UK, Portugal	Type *B* with dial selection and printed service signals but without automatic tripping of *B* subscriber's answer-back, which is instead done from the Madrid centre.
☐ Yugoslavia	Type *B* with keyboard selection, printed service signals and automatic tripping of *B* subscriber's answer-back.
☐ Italy	Type *B* with keyboard selection, printed service signals, automatic tripping of *B* subscriber's answer-back together with sending of date and time.

☐ Belgium, Holland, Norway	Type *A* with printed service signals, sending of register identity, automatic tripping of *B* subscriber's answer-back together with sending of time.
☐ France	Type *A* with printed service signals, sending of day number and time. Tripping of both *A* and *B* subscriber's answer-back.
☐ Canary Islands	*U 20* signalling on *ARQ*.

On an incoming call to the international transit centre in Madrid the outgoing country receives Type *B* signals.

The outgoing country can choose

- whether to get the call-confirmation sent and proceed-to select signals as two separate signals or as a combined signal
- to send selection signals in the form of teleprinter signals or dial pulses.

As will appear from the above, the primary purpose of an international transit centre is to interwork with different countries in accordance with the existing variant types of signalling systems.

Signalling Diagrams

Signalling on Subscriber Line

See fig. 8 for outgoing traffic, i.e. traffic from *A* subscriber *(TxA)*, fig. 9 for incoming traffic, i.e. traffic to *B* subscriber *(TxB)*. The signalling diagrams

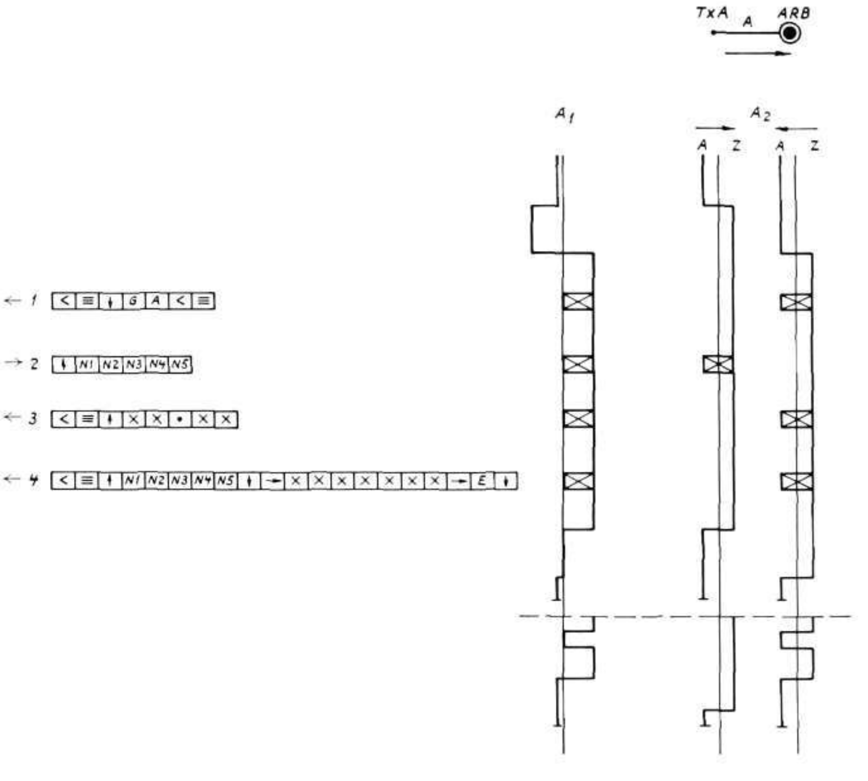

Fig. 8

Signalling on calling subscriber's line

ARB	Terminal exchange
TxA	Calling subscriber equipment consisting of teleprinter and control unit
A	Subscriber's line which may be either
A1	a single current line or
A2	double current line
→	Forward signalling path, i.e. from subscriber to exchange
←	Backward signalling path, i.e. in opposite direction
1	Proceed-to-select signal
2	Selection information, called subscriber's number
3	Time signal, hours and minutes, e.g. 21.10
4	Called subscriber's answer-back
N1, N2 etc.	Called subscriber's number

show the signalling both for single current A_1 and for double current A_2. The following description will relate to single current signalling. (All diagrams have a vertical time axis and A denotes start polarity and Z stop polarity.)

Outgoing Traffic

In the free line condition a current of about 5 mA flows through the subscriber's loop. On initiation of a call (depression of a button on subscriber's control unit which reduces the impedance on the subscriber's loop) the current rises to about 40 mA. The subscriber's line relay then operates. The terminal exchange *ARB* is through-connected. The time for the through-connection is about 400 ms. The superior transit centre is then called and at the same time the polarity of the subscriber's line is reversed for starting of the teleprinter motor. A printed proceed-to-select signal *GA* is sent after receipt of a proceed-to-select signal from a register in the transit centre, but a time of 2 seconds must have elapsed after starting of the motor to allow it to come up to speed.

The subscriber then sends the *B* subscriber's number preceeded by figure-shift (keyboard selection). A call-connected signal from the *B* subscriber is received in the form of his answer-back preceded by a time signal indicating hours and minutes.

After completion of the telex message the connection is cleared. The signalling diagrams shows, first, the procedure when the call is cleared by the *A* subscriber. Under the dotted line is shown the form of the signals when clearing takes place from the *B* side with the special signal mentioned earlier, and which in this case is used to prevent printing of characters on the *A* subscriber's teleprinter.

Incoming Traffic

On an incoming call the polarity of the subscriber's line is reversed and the current is raised to 40 mA.

The *B* subscriber receives a time signal, after which his answer-back is tripped. The signal diagram in fig. 9 shows, first, clearing from the *A* side and, under the dotted line, from the *B* side.

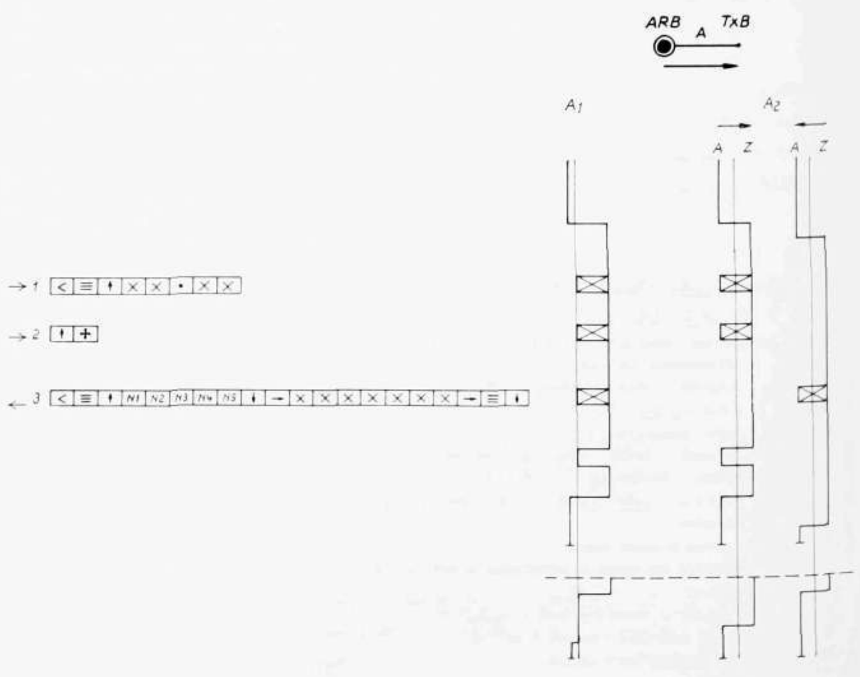

Fig. 9

Signalling on called subscriber's line

ARB	Terminal exchange
TxB	Called subscriber's equipment consisting of teleprinter and control unit
A	Subscriber's line which may be either
A1	a single current line or
A2	double current line
→	Forward signalling path, i.e. from exchange to subscriber
←	Backward signalling path, i.e. in opposite direction
1	Time signal, hours and minutes, i.e. 08.30
2	Answer-back trip signal
3	Called subscriber's answer-back
N1, N2 etc.	Called subscriber's number

Signalling from Terminal Exchange (ARB) to Transit Centre (ARM)

See the signalling diagram in fig. 10 which shows, first, the ordinary Type *B* calling, call-confirmation and proceed-to-select signals. In reply to the proceed-to-select signal the tariff zone (*T*) and class (*K*) are sent to the transit centre, and at the same time *GA* to the subscriber. After the sending of selection information by the subscriber and after tariff determination in the transit centre the code receiver in the terminal exchange is called by a pulse of 25 ms duration. When the code receiver has been connected to the repeater, an acknowledgement is received also in the form of a 25 ms pulse. The tariff is then sent in 2-out-of-5 code (denoted *Z* in signalling diagrams). The subsequent signals are Type *B* as already described.

Signalling From TxA to TxB

The signalling diagram in fig. 11 shows the signalling on the various circuits for establishment of a connection *TxA–ARB–ARM–ARM–ARB–TxB*. The signalling on the subscriber lines *TxA* and *TxB* is shown for single current.

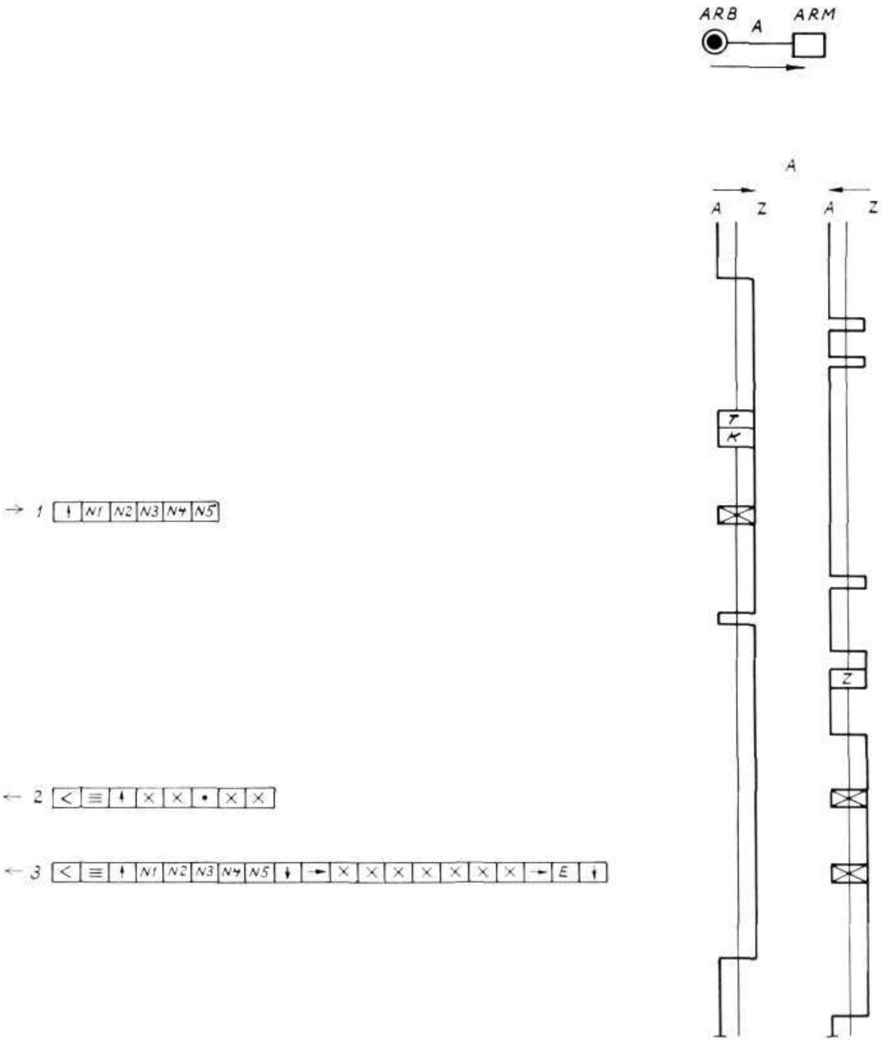

Fig. 10

Signalling on circuit between terminal exchange ARB and transit centre ARM for call from subscriber on ARB

A	Trunk circuit between the exchanges
T	A-subscriber tariff zone
K	A-subscriber class
Z	Tariff information Signal
1	Selection information, i.e. called subscriber's number
2	Time signal
3	B subscriber's answer-back
N1, N2 etc.	B subscriber's number

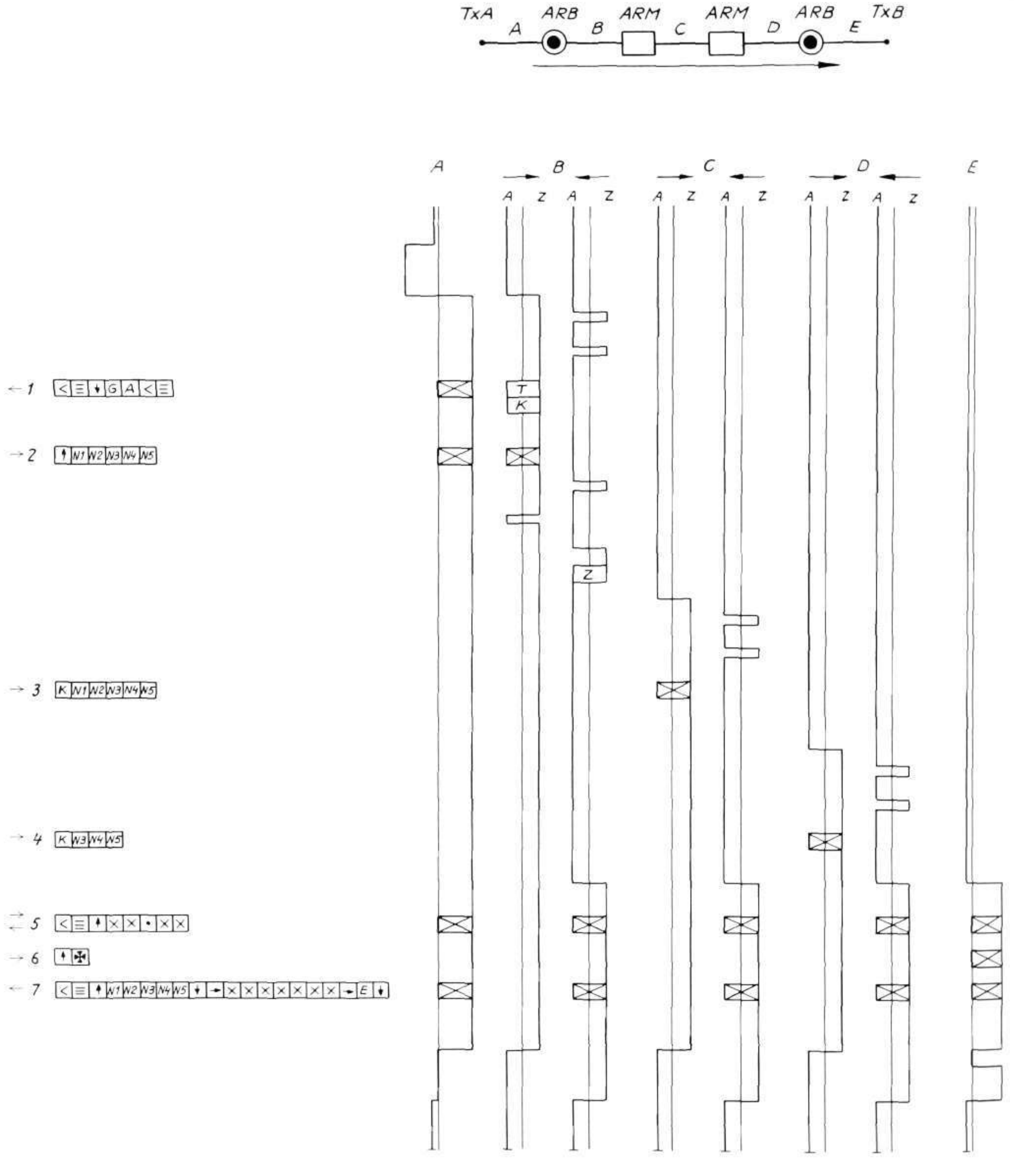

Fig. 11

gnalling for setting up a call between two ARB subscribers when the connection passes ough two transit centres ARM

TxA	A-subscriber's teleprinter and control unit
TxB	B subscriber's teleprinter and control unit
A	A-subscriber's line (single current)
B	Trunk circuit between ARB and ARM
C	Trunk circuit between the two transit centres ARM
D	Trunk circuit between ARM and ARB
E	B subscriber's line (single current)
T	A-subscriber's tariff zone
K	A-subscriber's class
Z	Tariff information signal
1	Proceed-to-select signal
2	Selection information, i.e. B subscriber's number
3	B-subscriber's number preceded by A subscriber's class K
4	The last three digits of the B subscriber's number and the class K of the A subscriber
5	Time signal
6	Answer-back trip signal
7	B subscriber's answer-back
N1, N2 etc.	B subscriber's number

The procedure for calling, transmission of proceed-to-select signal *GA*, tariff zone (*T*), class (*K*) and tariff information (*Z*) has been described above.

After receipt of *B*-number information from *TxA* the connection is set up through the transit centre (*ARM*) to a repeater on the route concerned. The signals for calling transit centre no. 2, call-confirmation and proceed-to-select signals are Type *B*. Digit transmission between the registers is done with teleprinter signals and the digits are preceded by the *A* subscriber's class signal. All five digits are transmitted.

The procedure is repeated through transit exchange no. 2. But only the last three digits, preceded by the class, are transmitted to the terminal exchange code receiver. The signalling on an incoming subscriber line has been described earlier. Finally it may be mentioned that the signalling diagram shows clearing by the *A* subscriber, which is the normal practice.

Signalling for Outgoing Semiautomatic International Traffic

The signalling diagram in fig. 12 shows the signalling on the chain of circuits *TxA–ARB–ARM*–international exchange in another country for semiautomatic international traffic.

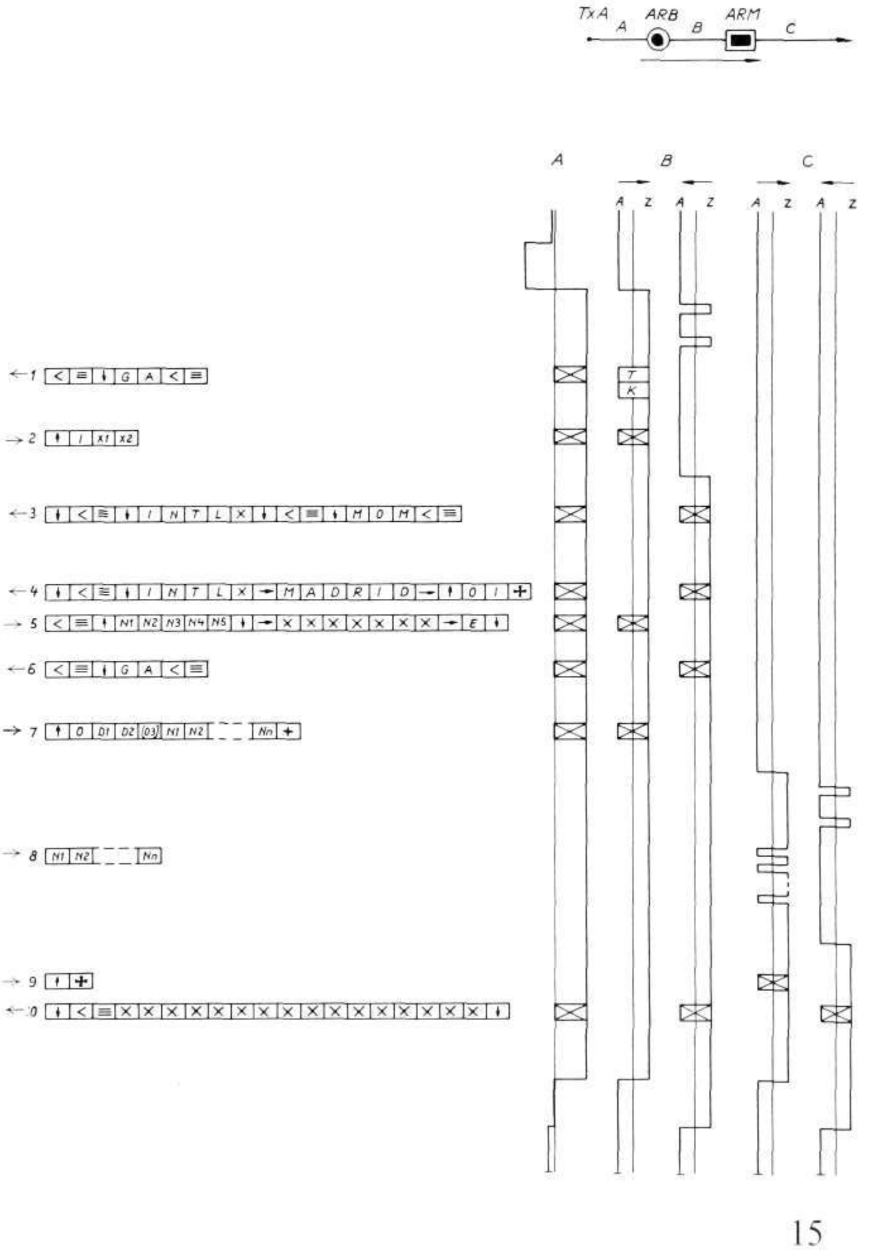

Fig. 12

Type B signalling on the chain of circuits A subscriber — terminal exchange ARB-transit centre ARM — international centre in an other country for semiautomatic international call from the A subscriber

- TxA *A-subscriber's teleprinter and control unit*
- A Subscriber's line, single current
- B Trunk circuit between ARB and ARM exchanges
- C International circuit
- T A-subscriber's tariff zone
- K A-subscriber's category
- 1 Proceed-to-select signal
- 2 Access code for semiautomatic traffic
- 3 Wait signal
- 4 Exchange and operator identity signal and answer-back trip signal
- 5 A-subscriber's answer-back with his number
- 6 Proceed-to-select signal
- 7 International number containing destination code, B subscriber's national number and +, which indicates end of selection
- 8 Dial transmission of B subscriber's national number
- 9 Answer-back trip signal
- 10 B subscriber's answer-back

In this case, after receipt of the proceed-to-select signal *GA*, the subscriber keys a three-digit number indicating that the connection is to be established by an operator in the outgoing international exchange (*ARM*).

After receipt of the numerical information by the register in the transit centre, which at the same time is international centre, a wait signal, INTLX MOM, must be sent to the *A* subscriber to indicate that the call has been received and queued. The backward channel must change to stop polarity immediately before this wait signal. As the connection will be charged by an operator, no tariff has been sent to the terminal exchange and consequently no tariff pulses will be sent to the subscriber's meter. From the charging point of view, therefore, the change to stop polarity is of no significance.

When the call, after being queued, arrives at the operator, the exchange identity signal and the number of the operator's position, e.g. INTLX MADRID 01, are transmitted, after which the *A* subscriber's answer-back is automatically tripped for identification of the latter.

The operator then connect an international register to the circuit, whereby a second proceed-to-select signal *GA* is sent to the *A* subscriber, who sends

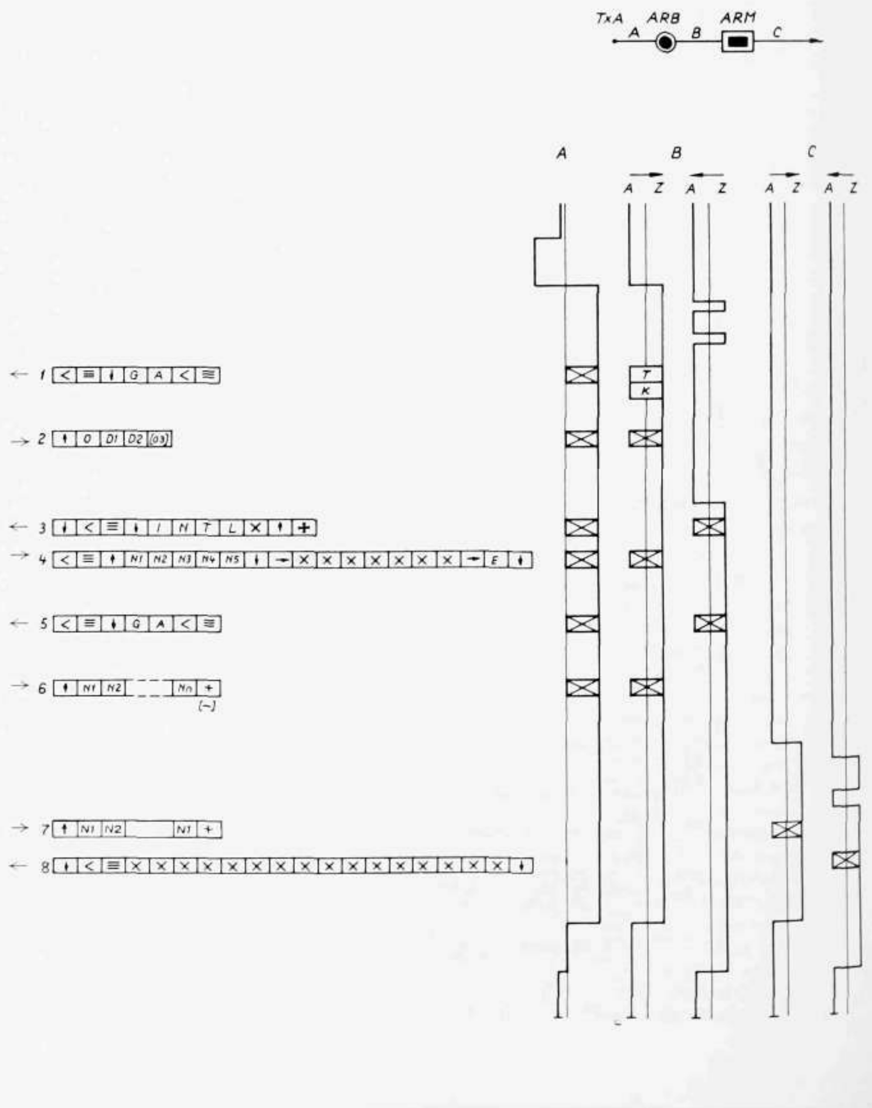

Fig. 13

Signalling on the chain of circuits A subscriber — terminal exchange ARB-transists centre ARM — international centre in an other country employing Type A signalling for a fully automatic international call from the A subscriber

- TxA A-subscriber's teleprinter and control unit
- A Subscriber's line, single current
- B Junction circuit between ARB and ARM
- C International circuit
- T A-subscriber's tariff zone
- K A-subscriber's class
- 1 Proceed-to-select signal
- 2 Destination code
- 3 Identity signal from international transit centre ARM and answer-back trip signal
- 4 A-subscriber's answer-back with his number
- 5 Proceed-to-select signal
- 6 B subscriber's national number followed bu end-of-selection + or −
- 7 B subscriber's answer-back
- 8 B subscriber's national number followed by end-of-selection +

the entire international number, destination code and national number proceded by figures shift and the digit zero, the latter in order to indicate an international call.

The signalling diagram thereafter shows the signalling in the case that the destination country has Type *B* signalling with dial selection and non-automatic tripping of the *B* subscriber's answer-back. After receipt of the call-connected signal the international register in the outgoing exchange sends, in this case, an answer-back trip signal to the *B* subscriber. The *A* subscriber thus receives the same call-connected signal, i.e. the *B* subscriber's answer-back, on both national and international calls.

Signalling for Outgoing Fully Automatic International Traffic

The signalling diagram in fig. 13 shows signalling on the chain of circuits *TxA–ARB–ARM*–international centre in another country with Type *A* signalling for fully automatic international traffic.

The diagram is based on the assumption of several international exchanges for outgoing traffic in the same country and that all the international routes do not exist in all international exchanges. After receipt of a proceed-to-select signal *GA*, therefore, the *A* subscriber must send the destination code for the called country. The destination code is preceded by figures shift and the digit zero.

The diagram is also based on central charging in the international centre by means of toll-ticketing equipment (the principle of charging on subscriber's meters for part of the international traffic may, however, also be used in the system).

Charging by toll-ticketing means that the backward channel to the terminal exchange, as in the semi-automatic case, can be reversed to stop polarity for signalling, in this case, of identity signal INTLX followed by an answer-back trip signal. The toll-ticketing equipment receives the answer-back for identification of the *A* subscriber, whose answer-back should therefore include the subscriber's number.

The second proceed-to-select signal *GA* is sent to the *A* subscriber, who then sends the *B* subscriber's number followed by either + (Combination 26) or – (Combination 1). If the latter combination is sent, the punched card is immediately set aside after clearing of the connection and the subscriber, after a renewed call to a service position, can be informed of the charge for the international connection.

Summary

As will be evident from this account L M Ericsson telex system contains equipments of such flexibility that within the framework of CCITT's recommendations, the exchanges can interwork with any other system. This applies equally on the national and international planes.

On the national plane *ARB* and *ARM* exchanges are interworking with other systems in Canada, Norway, Spain and Yugoslavia. Internationally a number of countries with different signalling systems are interworking with the intercontinental *ARM* exchanges in Montreal, Vancouver and Sydney, all three of which are connected to the Round-the-World Commonwealth Cable Scheme.

Similar interworking exists with the international transit centres of Type *ARM* in Ireland, Spain and Yugoslavia.

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Automatisation of the Australian Telex Network

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Technical and operating features of the automatic telex network, recently installed throughout Australia, are outlined.

The new automatic network uses the keyboard of the subscriber's teleprinter to send digit information for selection of the required number. Printed service codes are used in the system to inform the calling subscriber of the progress of his call, that is, a short printed indication is given on the calling subscriber's machine. The system uses a fast trunk signalling technique employing 5-unit start/stop code transmission for selection and rate-setting information. A simple numbering and charging basis has been employed. The characteristics of telex traffic differ significantly from telephone traffic, making less complex numbering and charging arrangements possible.

A feature of telegraph traffic since World War II has been the shift from public telegraph networks operated by telecommunication administrations, such as the Australian Post Office, to telegraph services in which the administration simply provides the necessary facilities, which subscribers themselves operate.

Subscribers with a closely defined sphere of interest and a heavy volume of traffic have, in general, chosen custom-engineered private-wire leased teleprinter services, and these were developed during and after the war. An obvious need developed for a general switching network which would cater economically for subscriber's more widely dispersed communication requirements, and for traffic loads lighter than those occurring on leased private-wire service. Further, such a network should permit efficient international connection and allow easy transfer of traffic, to and from the extensive Australian public telegraph network.

As a result, a service known internationally as telex was introduced on a manual switching basis in 1954 and phenomenal rates of growth in subscribers and in traffic developed in following years.

In the telex service the subscriber uses a teleprinter as the basic subscriber's instrument. Calls are then switched from teleprinter to teleprinter on a comparable basis to the switched telephone system. There are, of course, some significant differences in technique between a telex and a telephone switching system.

The telex system uses direct current signalling from the subscriber's terminal unit, and this has an important influence upon the transmission path through an exchange. Unattended reception at the subscriber's terminal is employed and affects exchange calling, clearing and holding conditions.

The capital cost of the telex system per subscriber line is very much greater than for a telephone system of the same size mainly because of the high cost of the teleprinter terminal compared with that of a telephone terminal.

Since capital charges play an important part in determining rentals, the rental charged for telex subscriber service is much higher than for telephone service. Consequently connection to the telex system is generally not justified unless the subscriber has a line loading much higher than is usual for a telephone subscriber. This affects trunking of telex switching systems which must be designed for heavy subscriber loadings.

Historical Background of Telex Service

Historically, subscriber-operated teleprinter switching systems awaited the development of a reliable and inexpensive teleprinter suitable for use in widely dispersed subscribers' offices. The start/stop principle was used in the 1920's in the United States and Europe to develop such teleprinters, which resembled an office typewriter in operation and required a minimum of auxiliary equipment.

Large telegraph switching networks developed in the 1930's, using these newly-developed start/stop page printers. The first of these was established by the Bell system in the United States in the year 1930. This network used direct current subscriber loops and voice frequency telegraph trunk connections and was designated the *TWX* system. This system continued to grow as a manual network until, by 1962, it had approximately 60,000 subscribers. The network in this year was converted to automatic operation through partial integration with the telephone switching system using tone signalling subscribers terminals.

In Europe fully automatic switching networks operating on a telegraph basis had been developed in the thirties, the first of these being the German network using the well known dial selection "neutral" supervision step-by-step switching technique which was followed later by many other countries. The Netherlands developed an automatic switching system for telegraphy using the common control switching technique and with the then novel feature of the use of the keyboard of the teleprinter for selection. Further the system provided for printed service code indications to be sent to the calling subscriber's machine as part of the supervisory signalling of the system.

In Australia the two main lines of overseas development were examined

- that of the Bell system in the United States toward integration with the telephone switching network using tone signalling terminal units with the teleprinter, and
- that of the rest of the world, toward internationally compatible automatic teleprinter switching networks using exclusively telegraph trunks.

The decision was made to adopt the latter course. Important reasons for this decision were that the Australian automatic trunk telephone network was some years behind the degree of automatisation achieved by the Bell system and automatic teleprinter switching on this basis would not have been possible on many routes for some years. Predominantly long distance telex traffic would have represented a heavy increment of load on telephone trunk routes and substantial additional capital investment. The United States' regulatory and competitive situation in telegraph communications was also thought to be an influence affecting the type of service provided there.

In 1948 the C.C.I.T.T. (The International Telegraph and Telephone Consultative Committee) had begun to draw the two separate lines of European development together in formulating standards which have been progressively extended with successive C.C.I.T.T. meetings, and the Australian system has been designed to closely follow these standards. In four respects the standards allow of no alternative. These are

- standardisation of the speed of transmission at 50 bauds.
- standardisation of teleprinter keyboard arrangements such that these must be in accordance with International Alphabet No. 2.
- standardisation on the principle of unattended reception with automatic answer-back verification.
- standardisation on the important principle that for international circuits the outgoing country should conform the signalling of the incoming country.

In other respects the C.C.I.T.T. drew up standards which allowed specified alternatives. The most important of these are

- the method of selection from the subscriber's machine which may be either by dial or from the keyboard of the machine.
- supervision of call progress at the subscriber's machine which may be either by printed service code or by visual indicator.
- the trunk signalling technique employed which may be one of three types.

In Australia, planning for an automatic telex service started in the late 1950's and, together with the Overseas Telecommunications Commission (Australia), specifications were prepared during the early 1960's for an internal system to be provided by the Post Office, and for an international gateway exchange to be provided by the Commission. The Post Office and the Commission, after examining tenders sought throughout the world, placed matching orders in 1962 for equipment from L M Ericsson. The Commission's international exchange commenced operation in September 1965, the Post Office internal network commencing service in June 1966 with approximately 2,500 subscribers. This network has since grown to approximately 3,200 subscribers.

Characteristics of Australian Telex Service

Telex is a service used primarily by industrial and commercial organisations and has a smaller penetration than the telephone service. Development studies show that it is most probable that there will be about 5,000 subscribers in the whole of Australia by 1970, increasing to about 11,000 by 1980. Compared

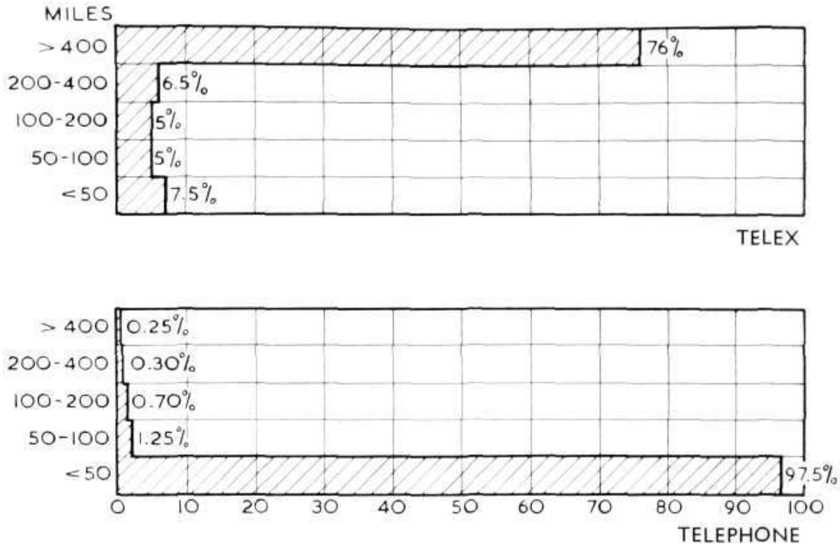


Fig. 1
Traffic distribution by distance

with the telephone service, where the community of interest centres primarily in the local service area, telex calls are predominantly made over long distances.

A marked difference was noted between telephone and telex traffic distribution by distance and is illustrated in Figure 1. Table 1 shows the traffic development by type of call, and several additional characteristics of telex traffic can be noticed from this table. It will be observed that telex traffic is increasing at a very rapid rate. Further, it will be noted that there is a significant traffic flow between the telex service and the public telegram system. This "printergram" load accounts for half as many switching operations at the present time as the trunk call component, although no longer growing so rapidly as more customers connect to telex. As previously observed, short distance traffic is relatively small.

The relationship between subscriber lines and total traffic has also been examined, and it is obvious that the automatic telex network is a very heavily loaded network compared with a typical telephone exchange system; in fact, following studies made on the manual system, the automatic telex network was based on an average subscriber loading in the busy hour of 0.15 erlangs per subscriber. This compares with a typical loading per telephone subscriber in a metropolitan exchange area of 0.08 erlangs per subscriber.

Table 1. Telex Service Calls Growth

Year	TYPE OF CALL					Total
	Local	Trunk	Printergram	OVERSEAS		
				Outgoing	Incoming	
1958–59	5,960	228,561	704,347	9,809	11,368	960,045
1959–60	11,324	344,330	832,334	26,092	30,442	1,244,522
1960–61	23,984	488,349	939,012	38,108	45,541	1,534,994
1961–62	36,210	696,482	1,095,643	50,123	59,713	1,938,171
1962–63	68,769	931,783	1,276,224	63,785	73,105	2,413,666
1963–64	101,315	1,311,023	1,417,473	84,325	98,585	3,012,721
1964–65	143,631	1,634,359	1,594,005	114,124	136,056	3,622,175
1965–66	176,000	1,849,600	1,737,634	133,530	152,440	3,701,460
*1966–67		3,592,610	1,781,884	182,050	195,916	5,752,460

* After automatisation of the automatic telex network in June 1966, the distinction between "local" and "trunk" disappeared as all calls are metered by periodic pulses applied to the subscriber's meter.

In the design of common control switching systems, it is necessary to carefully estimate the number of switching transactions which will take place since this represents the switching load on the common control system. In computing common control equipment quantities, it was assumed that automatisation of the telex system would cause call holding times to decrease, and a call-holding time of effective trunk calls of 2.1 minutes was used. An allowance has, of course, to be made for ineffective calls since these represent a switching load even though the call cannot be successfully connected, usually because the called subscriber is busy. This factor, coupled with the much lower call holding time on printergram traffic, has led to an overall planning average for all classes of traffic, effective and ineffective, of 1.2 minutes.

Number and Charging Principles

The group charging plans for telephone purposes used in Australia are based on the community of interest characteristics and, because of the preponderance of calls over distances of less than 100 miles, a fairly accurate assessment of the distances involved by these calls is required. Consequently the telephone charging system tends to make charges relate fairly accurately to distance for the shorter distance calls. As shown in Figure 1, telex in Australia has quite different community of interest characteristics. The community of interest now tends to be between business firms in the different business centres, and because the big cities are more than 40 miles apart, most of the traffic occurs in this mileage category.

Because there is so little traffic over short distances it is not so necessary to make charges relate accurately to distance for short distance calls. It was decided that advantage should be taken of this characteristic of telex traffic by establishing simple numbering and charging rules, which would lead to useful reductions in the cost of the system. In view of this a 5-digit closed numbering plan providing for the division of Australia into 44 charging areas, with charging discrimination obtained on examination of a maximum of 2 digits, was established. These charging areas, and the first and second

Fig. 2

Charging areas and charging centres

- • Zone centre & charging point
- 90 Telex numbering prefix
- —— Charging area boundary
- - — - State boundary

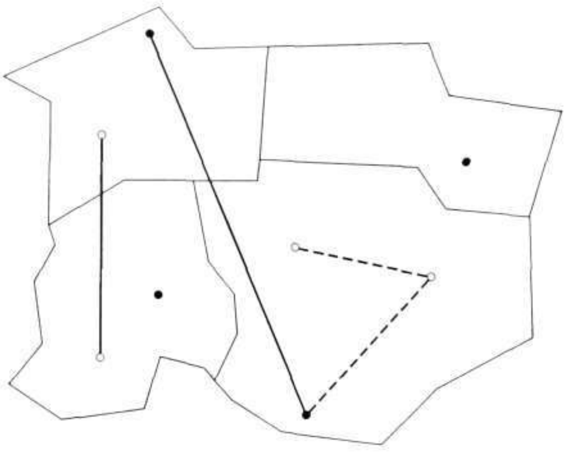
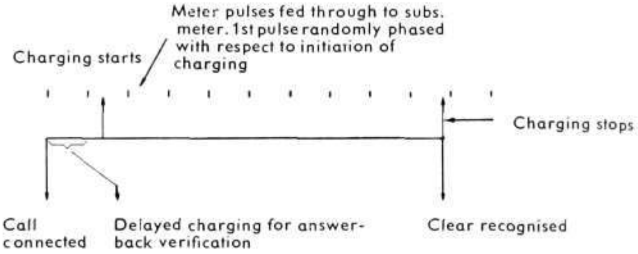


Fig. 3

Charging principles

- • Zone charging centre
- —— Zone boundary
- —— Zone to zone calls
- ---- Base rate calls



(*A*, *B*) digits allotted to them, are shown in Figure 2, which also shows the charging centre for each charging area.

The principle of charging is that the charge should be based upon the distance between the charging centres of the tariff zones in which the calling subscriber and the called subscriber are situated. Figure 3 shows this principle. Calls are periodically metered on a modified Karlsson basis which means that periodic pulses, the pulse period depending upon the distance between charging centres, are applied to the calling subscriber's meter.

Calls within a charging area are metered with the maximum pulse period. Concessional rates are provided for calls made between 6 p.m. and 9 a.m., except in the case of calls not exceeding 100 miles between charging centres.

The Australian system uses four periodic metering rates and a no-charge rate. Some categories of calls, such as calls to the printergram service (which permits transfer between the telex network and the public telegram network and therefore is of advantage to the Administration), calls to service positions, such as manual assistance, complaints, and directory enquiries are, of course, not charged and the equipment is arranged to take account of this requirement. The table of pulse periods for the various rates is shown in Table 2. Each pulse represents a 5-cent Australian charge.

Table 2: Meter pulsing rates

Distance between Zone Charging Centres	Number of Seconds between Pulses	
	Day	Night
Up to 100 miles	90	90
Over 100 and up to 200 miles	45	60
Over 200 and up to 400 miles	20	30
Over 400 miles	12	15

A feature of the Australian charging method is that the calling subscriber is able to check the answer-back returned from the called subscriber's machine without charge, since the commencement of metering is inhibited for a period of 5–10 seconds. As the automatic telex system itself calls for answer-back, a subscriber has the opportunity in this period to observe an incoming answer-back and immediately clear if he has not obtained the correct connection, thus avoiding charging. After this inhibition period, regular pulses randomly phased with respect to the commencement of the call are applied to the subscriber's meter.

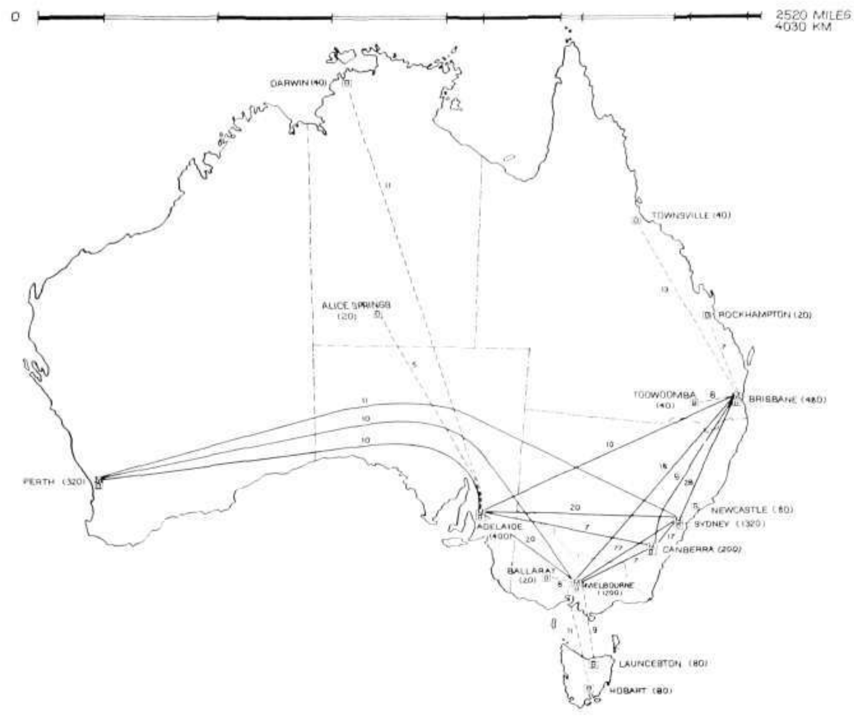


Fig. 4

The Australian automatic telex network, June 6th 1967

M = ARM transit exhange
B = ARB terminal exchange
—— = Intertransit trunks
- - - - = Terminal to transit trunks
(80) = Equipment installation provides for this number of subscribers lines

Type of Switching System

The system chosen for Autralia, after examination of world-wide tenders, was the L M Ericsson *ARB 10* system which consists basically of trunk exchanges of the *ARM 20* or *ARM 50* type with appropriate telegraph repeaters and registers working in conjunction with specially developed telegraph exchange subscriber stages known as *ARB 111*. Figure 4 shows the general network provided at 30.6.67. Terminal exchanges *ARB 111* have a maximum size of 400 lines, and a typical complete exchange installation such as that at Sydney consists of an *ARM* transit exchange of 600-line capacity to which are connected subscriber stages with a line capacity of 1,320 subscribers. The subscriber stages are provided as four 400-line dependent *ARB 111* exchanges (the fourth being incomplete) on the same exchange floor, together with an 80-line *ARB 111* exchange remotely located at Newcastle and with the capability of connecting many other dependent exchanges at various provincial centres as well as providing additional 400-line blocks in Sydney itself.

Type of Signalling System

The subscriber selection signalling system using the teleprinter keyboard was chosen for the Australian network mainly because of the advantages in speed of signalling and in the cheapness of subscriber terminal units arranged for this type of subscriber selection signalling.

Printed service code supervision is used with the following codes

OCC	Subscriber Busy
DER	Out of Order
ABS	Subscriber Absent – or Office Closed
NA	Connection Not Admitted
NC	No Circuits, or Trunks Busy
NP	Not a Working Line
MOM	Wait

The C.C.I.T.T. Type B signalling system was chosen for Australian trunk telegraph operation as described in another article in this issue.

Transmission Considerations

The object of the telex network is to provide economic low-error rate message or data communication with full interconnection possibilities between all subscribers and to the international network.

The main problems in achieving this objective in a telex system are the effects of cumulative distortion on built-up connections and the effect of circuit aberrations such as intermittent failures to start or stop polarity of a section or sections of the overall circuit. In practice, the first mentioned problem means that the number of telex trunks which may be connected in tandem has to be limited and the network structure arranged to conform with this limitation. Routing rules must be developed to prevent successive alternate routing since this would increase the number of tandem-connected trunks.

The Australian telegraph channelling network has been built up over many years and the quality of performance of equipment on different routes is not identical.

Allowance has been made for this, and for the possible introduction of distortion voice frequency telegraph systems in future years, by constructing the transmission plan in terms of distortion limits per link, and these are shown in Figure 5. The term *distortion* used in sequential telegraph transmission is a measure of the degree of departure of the significant instants of modulation from the ideal. In start/stop transmission a receiving machine translates signals in terms of the occurrence of instants of modulation following the commencement of the "start" pulse. Telegraph distortion is a measure of the correctness of timing of the pulse type transmission with respect to the leading edge of the release or start element.

Important features shown in Figure 5 are that the subscriber path to a transit exchange (which may be through a "remote" terminal exchange) shall not produce more than 12 % of gross start/stop distortion at the output of the terminating relay set of the transit exchange, and in the reverse direction shall have a margin to gross start/stop distortion of 30 %. Connections between first and final transit exchanges shall not exceed 13 % gross start/stop distortion and shall not traverse more than one other transit exchange. In order to maintain this rule alternate routing is limited to the original transit exchange. Further, alternate routing is prevented on international calls to ensure that gross start/stop distortion at the point of exit from the Australian national system, the international exchange at Sydney, does not exceed 22 %. Incoming international traffic is regenerated by the Overseas Telecommunica-

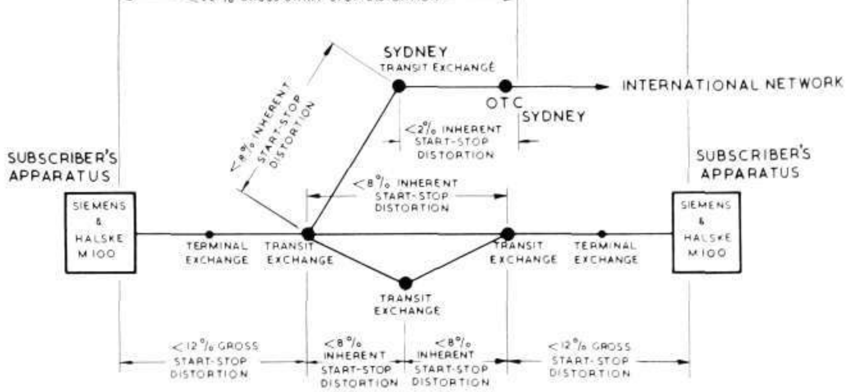


Fig. 5
Transmission plan

tions Commission (Australia) so that the input from the international trunks at the Sydney transit exchange should not be more than 5 %.

Unique Features

A comparison of Figures 2 and 4 shows that while there are 44 tariff zones in the Australian automatic telex system there are exchanges in only 11 of these, although there are some hundreds of subscribers in the remaining tariff zones. The distribution of these is such that they cannot be economically grouped together in exchanges in their own tariff zones. The telegraph channel network, which is not exclusive to telex but is still mainly governed by private wire and public traffic system requirements, often does not provide a convenient common grouping point for an exchange within the tariff zone; in fact the transmission considerations previously mentioned tend to make this undesirable. The telegraph channel network rather tends to form a simple star pattern in each State based upon the capital city as the centre of the star.

L M Ericsson offered an ingenious solution enabling these subscribers to be connected over voice frequency telegraph channels to capital city *ARB 111* exchanges but automatically metered according to their remote tariff zone origin. This is arranged in the signalling system by the automatic transmission of a 5-unit start/stop tariff zone code identifying the tariff zone of the calling subscriber, and this is used in the rate setting equipment, which is part of the parent *ARM* exchange, with the first two (*A*, *B*) digits of the called subscriber's number to determine the appropriate metering rate. This type of subscriber has become known as the "out of tariff zone" subscriber, and the automatically transmitted tariff zone code as the "T" code. The start/stop alphabet, of course, allows a number of these tariff zones to operate from one *ARM* rate-setting centre. Approximately 15 % of Australian subscribers are connected in this way.

A second feature of the Australian automatic system is a very flexible classification facility, enabling calls to be examined at the point of entry to the transit network, thus enabling certain classes of call to be barred from the general trunk network, or from particular trunk routes, as well as permitting calls to be examined at the terminating exchange for compatibility with the calling subscriber's individual class.

In addition the calling subscriber's class may be used to modify rate-setting, enabling special rates for particular classes of customer. As for the tariff zone mark, the class mark is automatically signalled as a 5-unit start/stop code and has become known as the "*K*" code.

It will be observed that the total information needed for rate-setting purposes is then the *T* code, the *K* code and the *A*, *B* digits of the called subscriber's number.

In a common control system such as that employed in the automatic telex network, the charging function and the routing function may be separated and although *T*, *K*, and *A*, *B* digits are examined for charging purposes, *T*, *K*, *A*, *B*, *C* and *D* may be examined for routing.

Special Subscriber Facilities

Group search facilities are provided at every terminal exchange, the only limitation on number allocation being that each number must be in the same 400-line *ARB 111* terminal exchange block.

A variety of special subscriber markings may be made at the exchange so that callers to these numbers receive special printed codes.

A subscriber may not wish to receive traffic for an extended period, as for example over a holiday period, and his line may have a plug inserted in such a way as to control the equipment to return the characters *ABS* when the number is called.

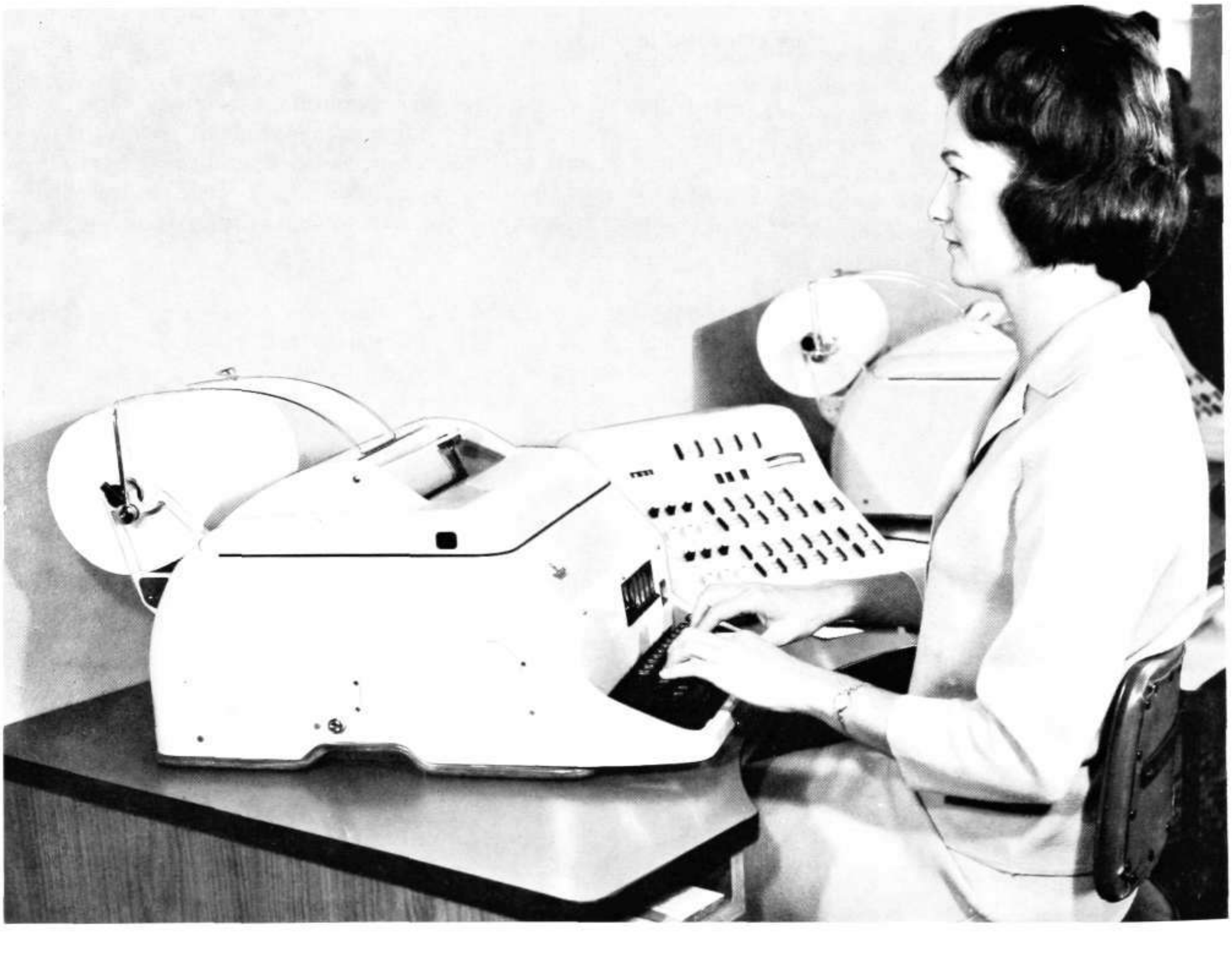
Similarly, a line which is not connected will return the C.C.I.T.T. standard service code *NP*, indicating "not a working line."

The classification facility may be employed to provide separate networks using the same switching equipment with complete or partial blocking of calls between respective groups of subscribers.

For example, a network could be provided for civil or military authorities with classification such that general subscribers to the telex service could not call these outlets, although the outlets on the special network could call within their own group or to subscribers of the general telex network.

Semi-automatic positions (Figure 6) have been provided at each transit centre to cater for a further range of special requirements and to handle service difficulties, the combined facilities in one location being referred to as a Telex Service Centre.

Fig. 6
Telex Service Centre — Manual assistance position



These semi-automatic positions provide for:

- Calls to be handled through an operator for toll-ticketing reasons. Examples of this class of call are conference/broadcast calls in which a calling subscriber may be connected to a number of other subscribers with full communication between all parties (conference) or with only the caller able to send (broadcast). The system of charging for these calls does not lend itself to fully automatic operation and for this reason semi-automatic facilities have been provided.
  Other calls in this category are press calls which are charged at a special concessional rate within Australia but which may be made from subscriber lines which handle full rate traffic on an automatic basis at other times.

- Assistance to subscribers who experience service difficulties. Operators, where possible, will connect the call for the subscriber, or suitably advise the customer about the service difficulty if this is not possible. Genuine fault conditions are filtered from service difficulties due to subscriber maloperation or to congestion on particular routes and faults are transferred to the appropriate engineering maintenance group. Subscribers with an unduly high occurrence of service difficulties can be put on line observation through these positions, and a continuous printer record kept of their traffic in order to analyse the type of difficulty experienced.

- Enquiry traffic which may concern national directory or national rate information. All international enquiry traffic is directed to the international telex exchange at Paddington, Sydney.

Although semi-automatic positions are provided for these main traffic loads all subscribers are connected as automatic exchange lines. No facilities are provided for terminating manual subscriber lines on these positions since the exchange system as a whole has been based upon a transmission plan which permits fully automatic connection between any two subscribers.

Regenerative repeaters can be switched-in on semi-automatically connected assistance traffic which may arise because of temporary transmission deterioration on a particular route.

Inter-Operation with the International System

The Australian national network connects to the international system via a single international gateway, the International Telex Centre, operated by the Overseas Telecommunications Commission (Australia) at Sydney.

An Australian subscriber making an outward call semi-automatically establishes the connection in two stages. The first stage is similar to a national subscriber call except that a 3-figure number commencing with zero is sent, e.g., 021. At this stage connection is made to the international exchange which automatically returns a printed service code identification followed by the "who are you" signal which causes the calling subscriber's "answer-back" to be tripped. The calling subscriber's "answer-back", which includes the subscriber's number, is used for identification purposes because these calls are not periodically metered at the originating exchange, as are national calls, but are toll-ticketed at the international centre. The Commission is thus able to present an itemised account for this high-rate international traffic.

This ticketing process is manual, but eventually the function will be automatic and calls will then be established completely automatically on some routes.

Following receipt of the calling subscriber's "answer-back", the international exchange sends the printed service code *GA* to the calling subscriber as an indication that he may now key the international number. The call then proceeds in much the same way as for a national call.

For international inward calls the international exchange is treated as though it is a service position connected to the Sydney national telex transit exchange and 5-digit selection information, preceded by the usual "Figures Shift" register opening character, is fed into the national telex exchange register to set up the call in the usual way.

Subscriber Terminal Equipment

As part of planning for the introduction of automatic telex service, the Australian Post Office studied teleprinters submitted against a Post Office specification from manufacturers all over the world. Finally the well-known Siemens *T* Type 100 page printer was chosen as the standard machine for the telex service and was introduced into the network in early 1960, with the intention that by the time the telex network was automatised, all machines would be of this type.

The machine, as offered, simplified the design of the subscriber's terminal control unit since the machine itself incorporates calling and clearing keys and circuit features such as centrifugally operated contacts in the machine to prove that the motor is running.

Among the optional features of the machine is the ability to add attachments such as a tape reperforator enabling incoming line signals to be copied on perforated tape, or for information to be prepared in both page and tape form as an off-line process using this machine. Also available is a tape transmission attachment and more than 50 % of all Australian telex subscribers hire machines incorporating both these attachments.

The terminal control units designed by the Post Office have two functional arrangements. The first of these is for machines without tape reperforation and transmission attachments and, in the case of single current signalling units, uses a very simple 2-relay control unit which is incorporated as part of the machine. For machines having tape attachments, a more complex terminal unit is used which permits the subscriber to prepare tape in a local circuit. The tape prepared may also be proofed by running it through the tape transmitter receiving page copy on the page section of the machine. This unit incorporates safeguards permitting an incoming call to take priority over local tape preparation but preventing the destruction of the tape in local preparation by giving warning of an impending call with a 3-second time delay before actual connection of the call. This allows the operator to clear tape under preparation before the incoming call is received.

The tape transmission facility with associated tape preparation is particularly attractive in international operation, a feature of Australian traffic, because at the rates charged for international connection the subscriber has a distinct incentive to use maximum line transmission speed and this is obtainable with tape transmission.

Two types of line signalling are employed.

The simplest of these, which is restricted to cable loops of less than 1,600 ohms resistance, uses single current loop signalling.

The second uses two path polar signalling and is used where the subscriber is beyond the resistance limit for single current signalling. Approximately 20 % of terminations are of this type. This type of signalling is also used in country areas where there is no exchange and subscribers are directly connected over a voice frequency telegraph link to a metropolitan exchange.

Conclusions

The automatic network provided has enabled the efficient handling of Australian telex traffic using a system capable of simple, logical expansion planned for progressive development over many decades.

Easy international connection leading shortly to fully automatic operation to a number of countries has been taken into account in this planning in which the Australian Post Office and the Overseas Telecommunications Commission (Australia) have worked in close liaison.

Australian interests in this respect have been well served by the work of the International Telephone and Telegraph Consultative Committee which provided the design basis for the system.

In particular the signalling system represents contributions from many countries in pursuit of the common desire for effective worldwide communications. The international flavour of communication projects is well illustrated by the Australian telex system. Apart from the design basis previously mentioned, the system uses teleprinters of West German design, terminal units of Australian design, switching equipment of Swedish design, transmission path repeating relays from C. P. Clare, Chicago, to Bell Laboratories design, and semi-automatic positions and switching plant of Australian design using components of United Kingdom, United States and Swedish origin.

The relative isolation of Australia from the centres of world communication manufacturing industry has led to a deliberate policy of encouragement of manufacture in Australia, and it is satisfying to note that all of the equipment referred to above, with the exception of the mercury wetted reed relays, was manufactured in Australia.

L M Ericsson, through its Australian subsidiary, performed a notable feat in carrying this project to completion with switching equipment manufactured in their Broadmeadows (Melbourne) plant, a plant which was established during the progress of the project.

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Corrugated Plastic Conduit Ducts

G. ÅBERG, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.315.616
621.315.671
LME 823

The corrugation of plastic ducts increases their radial rigidity. The L M Ericsson Network Department has developed a corrugating machine which produces from thin-walled plain ducts a corrugated duct with the same (or better) mechanical properties as a non-corrugated duct with walls 3–4 times as thick.

Non-corrugated plastic ducts are being increasingly used in outdoor conduits. They have many advantages: low weight, which reduces the freight and handling costs, no risk of corrosion of lead-sheathed cables, waterproof conduit, a certain flexibility, reduced friction, which allows longer distances between manholes, etc. These ducts, however, must have a fairly thick wall, which makes their price high. Corrugation permits the use of thinner-walled ducts and so reduces the price.

Non-Corrugated Plastic Ducts

Ordinary non-corrugated plastic tubing, 6 m in length, is a general commercial commodity in most industrial and certain developing countries. The diameter of the tubing varies. There are two reasons for this.

- Different diameters of duct are required in different parts of a local cable network. Near the exchange large-diameter ducts are required to accommodate multipair cables. This tendency will be accentuated through the use of light cables and, to a still greater extent, if copper conductors are replaced by aluminium. On the outskirts of the network and for secondary cable runs, on the other hand, a smaller duct diameter is sufficient.

- The second reason is that, with different diameters of duct, the ducts can be telescoped into one another and so form a more convenient transport package. This is an important advantage when the ducts have to be transported a long distance from the place of manufacture to the site of corrugation and installation. The freight cost for ducts of a single dimension is unreasonably high.

  A set of ducts *NTB 30101* contains nine ducts telescoped into one another. Their outside diameter varies between 70 and 110 mm in intervals of 5 mm.

Corrugating Machine

The aim in the development of this machine was that it should be easy to transport and install, easy to handle, and be easily adjustable for different duct diameters. The result is the corrugating machine *LVA 29901* (Fig. 1) which works on the following principles.

- The duct, firmly clamped in the machine, is caused to rotate.
- The duct is heated along a helix by five pointed flames from burners placed on a carriage which runs along the duct.
- The duct is subjected to a continuous axial pressure.

As these operations take place simultaneously, a helical corrugation is produced along the duct. The speed of rotation, the heating capacity of the flames and their distance from the duct, the speed of the carriage and the axial pressure must be adjusted to the duct diameter and wall thickness in order to produce the desired corrugation.

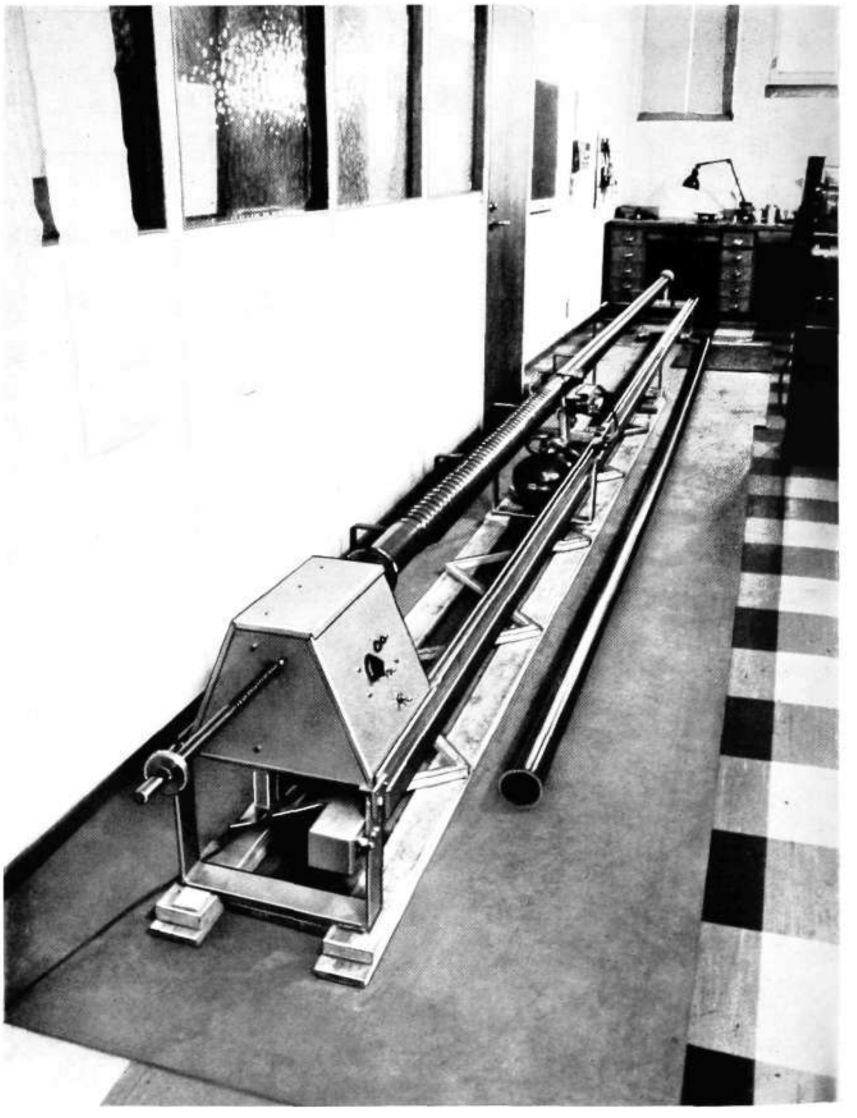


Fig. 1
Corrugating machine LVA 29901

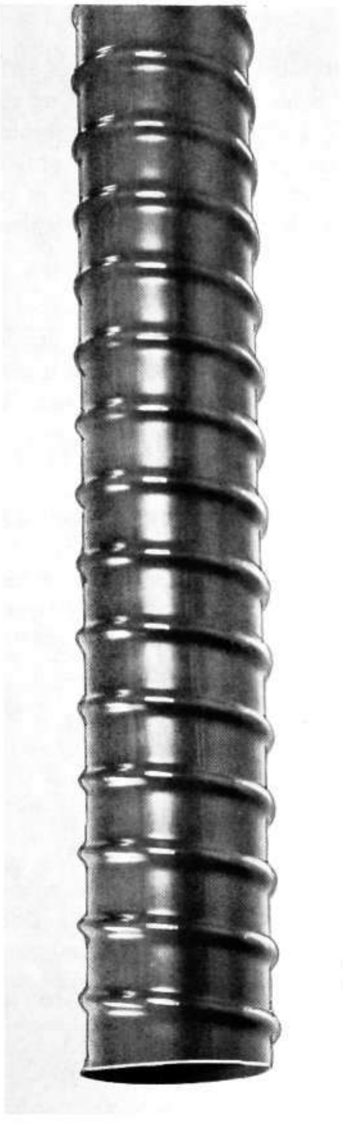


Fig. 2
Corrugated plastic duct

The corrugating process shortens the plastic duct by 6–7 %.

The machine requires a space of 1.5 × 8 m indoors or outdoors. In the latter case the site must be well protected against rain and wind. Indoors the machine is bolted to the floor. No special foundation is required.

The machine corrugates between 7 and 8 ducts per hour. One man can look after three machines. This means that the production per man and eight-hour shift is about 1000 duct metres of corrugated plastic duct, for which about 180 non-corrugated 6 m ducts are required.

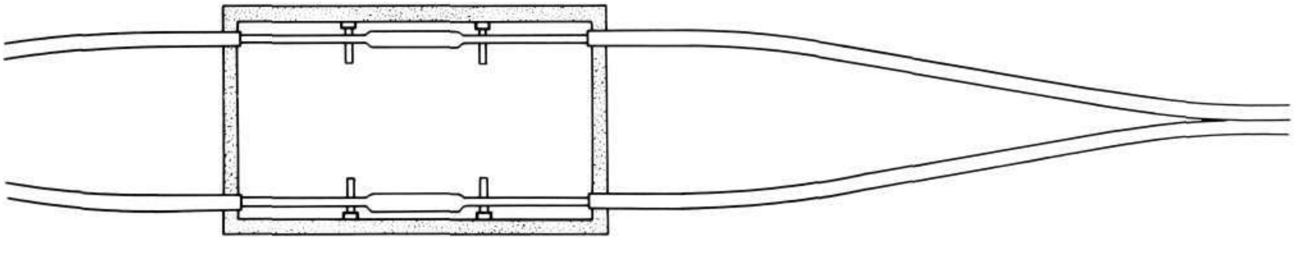
The machine is driven via a rectifier from a single-phase commercial lighting supply and has tappings for 110–240 V. The power requirement is about 0.2 kW. The burners are fed from a LP gas cylinder placed on the carriage. The LP gas cylinder suffices for about three days of operation.

Corrugated Ducts

Corrugated ducts have the following advantages compared with non-corrugated.

- ☐ Their radial rigidity is several times greater. The wall thickness can therefore be reduced, so allowing the use of cheaper ducts.
- ☐ A considerably better lateral flexibility is obtained, which permits their use in curved conduit. The minimum radius of curvature for a non-corrugated 90 mm duct is about 10 m, for a corrugated about 2.5 m. This results not only in a smaller number of manholes, since the conduit can follow curved streets and be taken round obstructions, but it also means that the cross-section can be changed between two manholes. The group of ducts can be divided 10–15 m before the manhole for example, one half being taken along one side of the manhole and the other half along the other side (Fig. 3). This has the great advantage that the cables can pass straight through the manhole along the two sides, an especially important point with heavy plastic cables, which are difficult to bend and are much more elastic than lead-sheathed cables.
- ☐ The longitudinal flexibility increases, which is an important point in conjunction with the embedment of ducts in a manhole wall or the like. As the expansion of the plastic duct is considerably greater than that of the surrounding soil, it is very difficult to embed a non-corrugated duct without the risk of strain caused by even moderate fluctuations of temperature. These strains are liable to produce untight inlets to manholes. The corrugated duct, on the other hand, functions like a concertina and the ends of the plastic ducts can be embedded without risk of tensile strains.

Fig. 3
Division of a group of ducts when passing through a manhole



Laying

The corrugated duct may have to be protected in different ways. When laid under pavement at a normal depth and under normal conditions no extra protection is necessary. But if the duct is laid under streets and/or if obstructions necessitate a shallower depth of laying, protection must be provided either in the form of embedment in lean concrete or of some form of protective tiles. Where there is a risk of rodents or insects attacking the plastic, the ducts must likewise be embedded in lean concrete.

To facilitate jointing, one end of the duct is tapered. The ends are first coated with a sealing compound *NTV 60021*. They are then jointed together by pushing the straight end of one duct into the tapered end of the next. The joint is thus gastight and watertight.

For embedment in a manhole wall or other concrete structure the outside of the duct is coated with resin *NTV 610* mixed with hardener *NTV 611*. Heated sand is then sprinkled over the resin. The resin solidifies and binds the grains of sand so that the duct is covered with a firmly adhering layer of sand. The duct is then embedded in the concrete and a gastight and watertight inlet is obtained.

Split Ducts

If cables are already installed in the conduit, a longitudinal slot is made in the duct with a metal saw. The split portion is laid around the cable. Owing to the corrugation the duct reassumes its original form. For alterations to cable plant the cables can be temporarily protected in the same way.

Summary

Non-corrugated plastic ducts have been used for several years in conduit and have many excellent properties. The result is still better, however, if the duct is corrugated. Corrugation increases the radial rigidity and the lateral and longitudinal flexibility. It results in a better and cheaper conduit.

The basic material is non-corrugated PVC tubing, which is made in many countries.

To reduce the cost of transport to the construction site the non-corrugated ducts are packed in sets of nine ducts 6 m in length and of different diameters, telescoped into one another. Corrugation is done on site in a machine specially developed for the purpose. A cheap plastic conduit can thus be constructed even at places where there is no manufacture of non-corrugated duct.

Details concerning the construction and operation of the corrugating machine *LVA 29901* and the dimensions and properties of the non-corrugated plastic ducts *NPB 30101* will be found in Catalogue 742, Section 23, Supplement 1, and Section 12, Supplement 1. A detailed description of the laying, jointing and embedment of the corrugated ducts will be found in instruction N 1531–073.

ERICSSON News from

All Quarters of the World

New Successes for Ericsson do Brasil

The signing of the ARM contracts for Rio de Janeiro and São Paulo. (From left) Sr. Geraldo Nóbrega, EDB, Sr. Jorge Marsiaj Leal, EMBRATEL, Col. Pedro Leon Bastide Schneider, Chairman of CONTEL, Sr. José Maria Couto de Oliveira, EMBRATEL, Mr. Ragnar Hellberg, EDB, and General Laundry Salles Conçalves, Chairman of CTB.

Ericsson do Brasil have had great successes in the expansion of local telephone plant and have sold equipments for automatic local exchanges totalling more than 550,000 lines.

The formation of the federal enterprise, EMBRATEL, opened the way to complete planning also of the national trunk network.

At an early stage it became clear that the traffic between the large cities must be converted to fully automatic operation. Manually served connections between, for example, Rio de Janeiro and São Paulo would require at least 6000 operators.

When EMBRATEL and other large telephone enterprises requested tenders for automatic switching equipments for trunk traffic, EDB was already well prepared.

The first success was at Curitiba, where in August 1967 EDB's tender was accepted for an ARM 20 exchange for 1600 trunk lines and charging equipment of toll-ticketing type.

A similar contract was signed in the following month for an exchange at Pôrto Alegre for 1000 lines.

In October the company had a further success. It received an order for a trunk exchange system for the entire province of Paraná. The contract signed with TELEPAR was for five ARM exchanges totalling 1960 lines and charging equipment. The deal also included interworking equipment for thirteen towns.

At the beginning of 1968 EDB achieved its biggest success hitherto within the trunk exchange field with its winning tender for the new transit centre at Rio de Janerio. The result was a contract for an ARM 20 exchange for 3600 trunk lines with associated charging equipment.

At the same time EMBRATEL ordered corresponding equipment for no less than 4200 trunk lines for São Paulo.

EDB has now also gained a contract for ARM exchanges for 1200 lines with charging equipment for the cities of Salvador and Recife.

The first of the transit exchanges sold is expected to be ready for operation by early 1969. The total amount of the order is around 1000 million kronor.

Telefonfabrik Automatic A/S Becomes GNT Automatic A/S

An agreement has been concluded between Det Store Nordiske Telegraf-Selskab A/S and its Danish shareholders, who have hitherto held 51 % of the share capital of Telefonfabrik Automatic A/S, concerning the takeover of all these shares. The remaining 49 % of the shares in Automatic, which were acquired by the Ericsson Group in 1946, are not affected by the transaction and remain in the possession of the Group.

Through concession and other agreements with a number of countries Store Nordiske has for some years owned international telegraph lines on which there has been a considerable quantity of traffic. The company has its own submarine cables in Europe, East Asia and the North Atlantic. Its activities also comprise the development, construction and sale of telecommunications equipment, and for some years also of teleprinters. This latter sector of its activities, which hitherto has been conducted under the name Great Northern Telegraph Works, will be transferred to Automatic A/S.

The cooperation thereby established between the Ericsson Group and Store Nordiske provides prospects of a continued expansion of Automatic's activities.

New Factory Opened at Östersund

L M Ericsson's new factory at Östersund was opened on January 17 by Cabinet Minister Rune Johansson in the presence of representatives of local authorities of the county, headed by the Governor, Anders Tottie.

The Telecommunications Administration was representated by Director General Bertil Bjurel, and L M Ericsson by the Chairman of the Board, Dr. Marcus Wallenberg, and the President of the Company, Björn Lundvall.

The new factory will replace the previous plant at Huddinge just south of Stockholm.

The manufacture at Östersund will comprise chiefly ferrite materials for loading coils, filter coils and transformers, and also complete loading coil equipments.

The Östersund factory is the sole producer of ferrite components within L M Ericsson.

From the opening ceremony: (from right) Dr. Marcus Wallenberg, Minister of the Interior, Rune Johansson, Director General Bertil Bjurel, Telecommunications Administration, and Mr. Björn Lundvall, President of LME.

The factory at Östersund

Bror Lindén in Memoriam

Bror Lindén

It was with sorrow and a sense of loss that we received the news of the death of Bror Lindén. In him we have been deprived of still another pioneer in the field of line plant construction. He was one of those who had a share in the designing of our line plant construction system and later, as constructional engineer, in taking it out into the world.

Bror Lindén was born in 1884, took an engineering degree in 1908, served as lines engineer at Stockholms Telefon in the years 1908–1918 and was assistant director at H. T. Cedergrens Industri AB from 1919 to 1921. He thereafter devoted his energy principally to affairs abroad. From 1922 to 1925 he was Technical Director of L M Ericsson's operating company in Poland at that time and built or modernized the local line plants in several Polish cities. He then moved to southern Italy where from 1926 to 1932, as head of Compagnia Installazioni Reti Telefoniche (CIRT), he built local line plants for the account of SET. After a few years in Sweden, where he assisted in the cabling of the Swedish Railways' telephone network in conjunction with the electrification of the railways, he went abroad again, this time to Colombia, where from 1937 to 1941 he planned and built the line plant for the City of Medellín. This was the first large local line plant of LME type in that part of the world and was therefore a reference plant not only for Colombia but also for neighbouring countries.

From 1941 until he left his post in 1954 he served as Installation Manager of the Network Department. The main part of his time was spent on the leadership from Stockholm of installation work abroad. He gave generously of his great fund of experience, not only to his direct colleagues but also to the other members of the department.

All of us elder members of the company who had the advantage of knowing Bror Lindén will remember him with a sense of loss as a capable engineer and a man of great industry, but perhaps above all as an unusually positive personality for whom difficulties existed only to be overcome and who undertook every task in a spirit of confidence and good humour.

His memory may fade but will never be effaced as long as we live.

Gunnar Åberg

Fully Automatic Trunk Traffic in Venezuela

The official opening of CENTRO NACIONAL DE TELECOMUNICACIONES in Caracas was combined with the initiation of subscriber-dialled trunk traffic in Venezuela. The photograph shows the President of Venezuela, Dr. Raúl Leoni, making the inaugural calls to the Governors of the Provinces of Carabobo and Aragua. (Left) The Minister of Communications, Dr. Juan Manuel Dominguez Chacin, and (right) the President of CANTV, Sr. Jorge Armand.

Compañía Anónima Nacional de Teléfonos, Venezuela (CANTV), has initiated the largest development project hitherto in Venezuela, comprising the total modernization and automatization of the telecommunications network.

During the period 1966–1970 CANTV is investing some 1000 million Swedish kronor, a record investment which within a few years will make Venezuela one of the highest developed telecommunications countries in the world.

The first stage of a national and international telecommunications centre, Centro Nacional de Telecomunicaciones, was completed on December 15, 1967. In conjunction therewith the first four transit centres under project MC-LD-15 for the introduction of fully automatic trunk traffic throughout Venezuela were opened. At the same time the first local exchange of L M Ericsson's crossbar system ARF 102 in Venezuela was put into service.

The first L M Ericsson crossbar exchange of system ARF in Venezuela, named Rómulo Gallegos after one of Venezuela's greatest modern authors. The exchange has an initial capacity of 10,000 lines.

Subscriber-dialled trunk traffic will be successively introduced in the twenty-nine largest towns of Venezuela during the next year, and LME has an important role in this project in the capacity of supplier of all automatic transit exchanges, comprising a multiple capacity of 6600 lines.

The installation of this equipment will mean that Venezuela will be the first country in South America to have a nationwide all-automatic trunk network. Large investments have also been made in radio links.

The plans include the expansion also of local exchanges, for the continued automatization of which L M Ericsson is supplying equipment totalling 69,000 lines of system ARF, of which 42,000 lines in Caracas.

The first ARF exchange was cutover on December 15 in conjunction with the opening of Centro Nacional – only 10 months after the signing of the contract.

The first stage of the new Venezuelan telecommunications centre, CENTRO NACIONAL DE TELECOMUNICACIONES, was officially opened on December 15, 1967, by President Leoni. The photograph shows the main building of CANTV on Avda. Libertador, Caracas.

Dirivox and Centrum in the Soviet Union

The LMS intercom systems Dirivox and Centrum were introduced on the Soviet market in 1966 at an international exhibition in Moscow where both L M Ericsson and AB Gylling & Co. were represented.

In August LMS received a Russian order for intercom equipment amounting to some 400,000 kronor.

The types of intercom systems marketed by LMS are entirely new on the Russian market and have aroused a great interest. As modern efficiency methods are being increasingly applied to office routines in the Soviet Union, it may be expected that the import will increase.

LME Enters into Cooperation with Hungary

Representatives of L M Ericsson and state organizations for the Hungarian telecommunications industry and foreign trade signed at the end of January a series of agreements representing a total value of some 40 million kronor. Apart from direct deliveries of goods the agreements contain clauses providing for technical cooperation with the Hungarian telecommunications industry. All agreements, however, are dependent on the approval of the authorities.

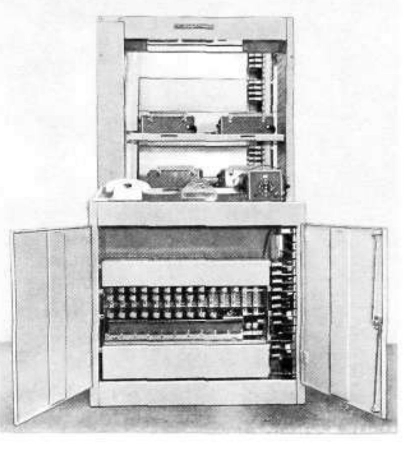
Centrum Exchange to Orly

Centrum Electronics S. A., Paris, have received an order for a CE 800 exchange for the large Orly Air Port in Paris. The exchange will be built initially for 300 lines but will have facilities for extension by an additional 500 lines.

The cut-over is expected to take place at the beginning of April 1968.

Prototype of Education and Information Exchange

The ERGA Division of L M Ericsson has recently produced a laboratory model of an education and information exchange constructed on the modular principle. The exchange



is made up of units of 10 calling lines and may comprise up to 50 information sources. It can be connected to an ordinary telephone exchange, which makes it accessible also for external calls.

Gunnar Vikberg

New Head of EDB

Mr. Gunnar Vikberg, Head of the Sales Department of the Long Distance Division, has been appointed Head of LME's Brazilian subsidiary, Ericsson do Brasil Comércio e Indústria S. A., as from the spring of 1968 in succession to Mr. Ragnar Hellberg, who will take on another appointment within the Group.

New head of the Sales Department of the Long Distance Division is Mr. Curt Green. His appointment started as from January 1, 1968, when he was nominated Chief Engineer.

Wolf Kantif in Memoriam

Wolf Kantif

Through the sudden death on October 4, 1967, of Wolf Kantif, Ericsson do Brasil lost a valuable member of its staff and his colleagues a greatly estimated friend.

Through his enthusiasm and persevering work Wolf Kantif actively contributed to EDB becoming one of the most important Brazilian companies within telephony.

When Kantif was taken on in the early thirties EDB had sold only one automatic exchange. The first success came in 1935 through a contract for a 1000-line exchange for Fortaleza. Today Fortaleza has 16,600 lines served by four exchanges.

Kantif's great passion was telephone business, but he had many other interests as well, among which football. It was at a football match that Kantif was contacted by the then head of EDB, Karl R. Lanneborn, and taken on by the company.

A few years ago Kantif became Citizen of Honour of Rio de Janeiro – a distinction given to few foreigners. Kantif was a British subject but found his main circle of friends among the inhabitants of the country.

We pay allegiance to Kantif's memory. He was a devoted member of the company's staff and an unusually harmonious and friendly person.

S.G.F.

The Ericsson Group

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Please turn page for list of associated and co-operating enterprises and technical offices

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CONTENTS

On cover: L M Ericsson loudspeaking telephone, the ERICOVOX, with key-base DYA 11 for telephone attendance and conference system. An ERICOFON for non-loudspeaking conversation.

Telephone Attendance and Conference System DYA 111

A. SVENSSON, L M ERICSSON TELEMATERIEL AB, STOCKHOLM—TYRESÖ

UDC 621.395.348
LME 837

System DYA 111 is an auxiliary to a non-loudspeaking or loudspeaking conventional telephone set. It facilitates connection of several telephone lines (lines to the public network, to PABX's and/or PAX's) to one instrument. Direct access lines to the most frequently called extensions can also be provided, as well as enquiry, transfer and conference facilities. It can also be used for operation of, for example, door signals.

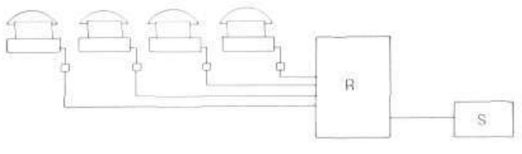

Fig. 1
Complete system with key-bases, relay equipment (R) and power supply equipment (S)

System *DYA 111* consists of a key-base or key-bases for placing under the telephone set, central relay and power equipment, and cabling (Fig. 1).

The key-base has eight keys, the functions and purposes of which the subscriber can largely decide himself. This flexibility reduces the number of units required for telecommunication and office service on the subscriber's desk. If more than eight keys are required, two or more key-bases can be installed.

Telephone Attendance

System *DYA 111* was developed in order to meet the growing demand for telephone attendance, with one or more persons individually or jointly attending to incoming calls to predetermined extensions. With conventional telephone arrangements this usually means that several extra telephones and accessories must be installed. All that is required on the subscriber's desk with system *DYA 111* is one or two key-bases placed under the ordinary telephone set.

Effective telephone attendance equipment must be so designed that calls to a subscriber in his absence can be *directly* transferred to the extension or extensions on duty.

With system *DYA 111* telephone attendance can be arranged both for external traffic through the *PABX* and for internal traffic through, for example, a *PAX*. Internal traffic attendance is important in this connection, otherwise the subscriber would use the *PABX* for internal calls.

Intercom telephones, i.e. loudspeaking telephones with push-buttons, are now used predominantly in Sweden for internal traffic. The Dirivox and Centrum intercom telephones made by L M Ericsson offer secretary transfer arrangements. In the absence of the subscriber, or when he wishes to be undisturbed, he can switch his intercom calls to be answered by his secretary.

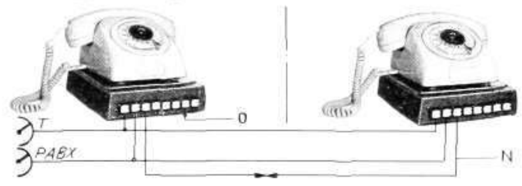

Fig. 2
Executive and secretary equipment with lines both to the public exchange and to the PABX

T Public exchange
O Switching key
N Direct line

A simple type of telephone attendance system is shown in Fig. 2.

By means of a switching key (O) the ringing signal is directed either to the executive *or* to the secretary. A visual call signal always goes to both.

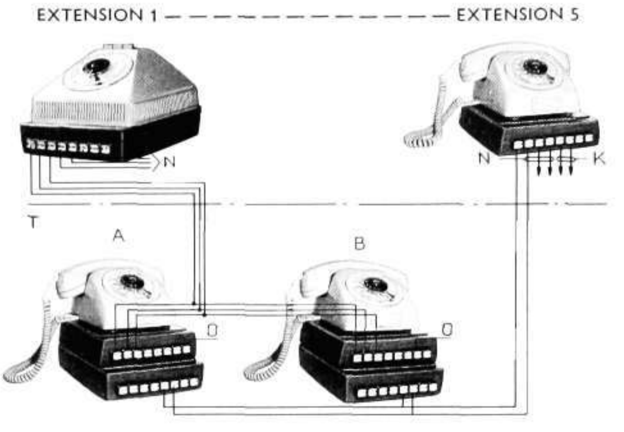

Fig. 3
Attendance centre
N Direct lines
K Office signals
T Attendance

An important step in office rationalization is to arrange telephone attendance for a number of persons at certain central points in the company. Within each such attendance centre there are two (or three) persons, each of whom can handle the entire attendance service (Fig. 3).

The advantage of this arrangement is that, in the absence of A for example (lunch, holidays, illness etc.), B can take over the entire attendance service.

Fig. 4
Keyset for key-base DYA 11
S Secretary
P Post
B Messenger
U Engaged
O Switching key
R Restore key

If A and B are in separate rooms and A is normally in charge of the attendance service of, for example, extensions 1 and 2, and B of extensions 3, 4 and 5, both A and B have a switching key O. If A presses this key, the ringing signal on *all* A's lines (including the direct-call lines) is switched from A to B. If B presses key O, the situation is reversed.

By using system *DYA 111* for telephone attendance the conventional extra accessories in the form of desk switches, parallel telephones, executive/secretary telephones, switching relays etc. are not required. The user of system *DYA 111*, therefore, need not have his desk cluttered up with a number of telephone sets and switches. Only *one* telephone set of ordinary *C.B.* type is required. The telephone is placed on a key-base *DYA 11*. By adding an ERICOVOX, loudspeaking conversations can be carried on on all telephone lines connected to the key-base.

Office Signals

System *DYA 111* is also designed to provide for a subscriber's *entire* requirement of office signals (engaged, secretary, messenger, etc.), see Fig. 4.

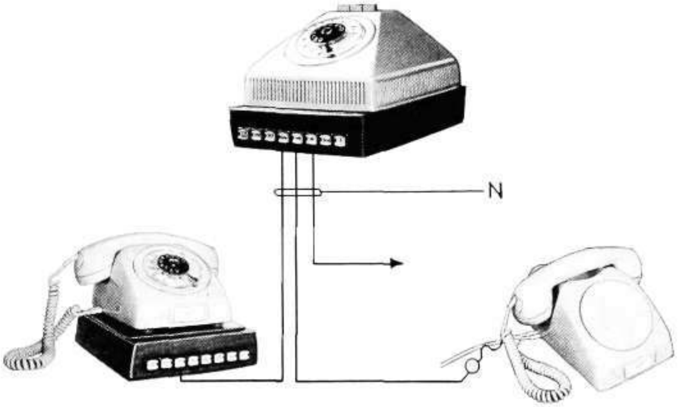

Fig. 5
Key-bases DYA 11 with direct lines

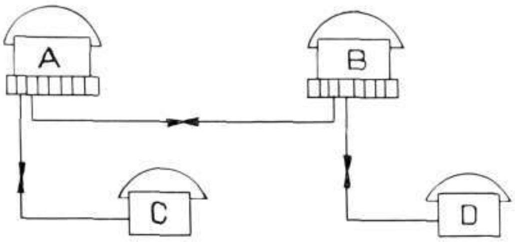

Fig. 6
Chain conference

Direct Lines

If there is no need for office signals, the keys can instead be used for direct-access internal lines between the key-bases. If connection is desired with a person not equipped with key-base *DYA 11*, the latter is given an ordinary telephone set, e.g. a DIALOG without dial (Fig. 5).

As the executive generally has *one* direct line (to a secretary or attendance centre) no extra relay equipment is required for the additional direct lines desired. Every direct line requires two wires only. No intermediate relays are required to establish connection between two key-bases. All connected lines have secrecy of conversation.

Conference

Conferences can be set up between up to five direct lines by pressing the line keys of the participants desired.

Fig. 6 shows how C and D are brought into a conference during a conversation between A and B. C is switched into conference by A, and D by B, a chain conference.

With the Telephone Administration's permission, external subscribers can also be included in the conference shown in fig. 6 by installation of auxiliary equipment. This equipment also permits the user of a *DYA 11* set, with two external lines, to bring two external parties into a conference with himself alone.

Combination Facilities

The key-bases are made in two types–a short model fitting both the earlier telephone set type *DBH* and the DIALOG, and a longer model fitting the ERICOVOX loudspeaking telephone. As the shorter model can be placed on top of the longer, 16 keys are available for the non-loudspeaking telephone. If an ERICOVOX loudspeaking telephone is added, and placed on a separate key-base, 24 keys are available for coding. The key-bases can also be mounted in a telephone desk (telephone desks are not supplied by L M Ericsson), as shown in Fig. 7.

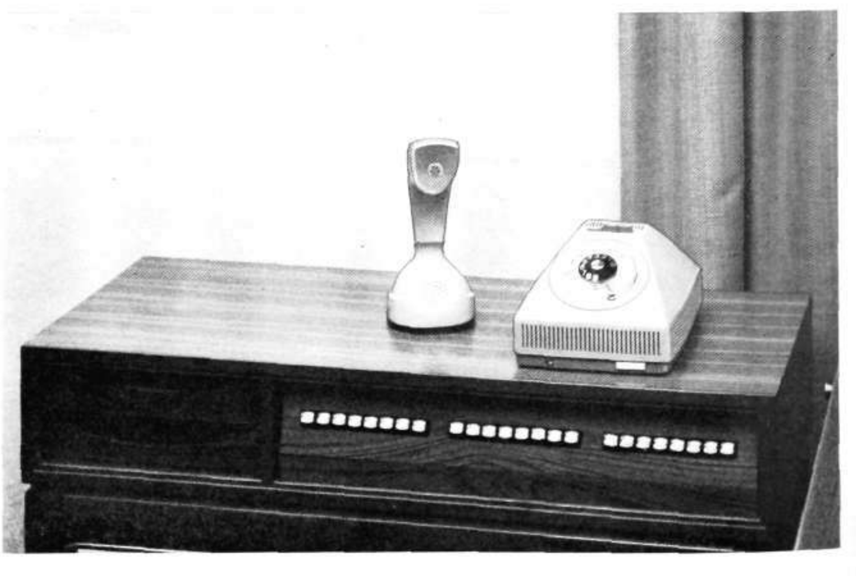

Fig. 7
Key-bases DYA 11 mounted in telephone desk

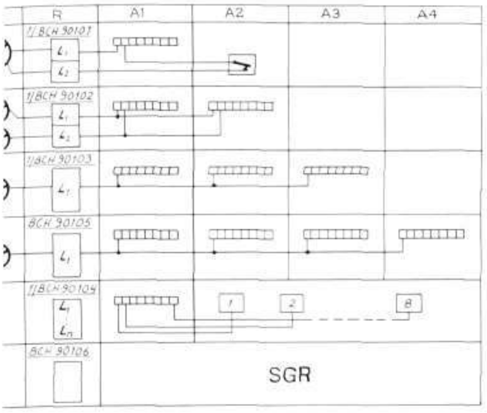

Fig. 8

Relay sets, applications

T Public or private exchange
R Relay sets
A 1-4 Extensions 1—4
SGR Relay set for lamp signals

System Design

The relay equipment required for the system is placed in one or more relay cabinets *BDC 595*, each accommodating 10 plug-in relay sets. The traffic facilities for a given system will depend on the choice of relay sets. The various relay sets are shown in Fig. 8.

Relay set *1/BCH 90104* for direct lines can be combined with other types of relay sets, which allows a very flexible design of the system (Fig. 9).

Power Supply Equipment

The system operates off 48 V DC and 70–90 V AC for signalling. If these voltages cannot be obtained from the exchange a separate battery eliminator must be installed. If mains failures are frequent, battery and charger are recommended.

Summary

System *DYA 111* is an auxiliary equipment for a non-loudspeaking or loudspeaking telephone set, which allows connection of external, internal and direct lines with enquiry, transfer and conference facilities. The keys which are not used for telephone communication can be used, for example, for office signals.

The user of a key-base with one line to the public exchange, one line to the *PABX* and a number of direct lines can

- ☐ press *one* key (the switching key) to arrange for attendance of incoming calls from the public network as well as calls from the *PABX*. Important calls are announced to the user by the secretary (or attendance centre) on a direct line. For outgoing calls the telephone can be used in the normal way.
- ☐ make enquires on the direct lines during a conversation with an outside or a *PABX* subscriber.
- ☐ set up a conference between direct lines. If the telephone administration permits, external subscribers can also be included in these conferences.
- ☐ if the telephone attendance is performed by two secretaries (attendance centre) the user can call *both* on *one* direct-line key. The call is signalled by a buzzer only at the secretary which for the moment is attending to the service. Secrecy of conversation naturally exists also on this type of connection.
- ☐ use the *PABX* line for making an enquiry call to any extension during a conversation on the public network. If the Telephone Administration permits, a conference can be set up between the three participants.
- ☐ during an important conversation on one of the external lines the user can press the switching key, whereupon incoming calls on "the other" line are directly routed to the secretary. The latter has lamp indications on *both* lines and is thereby informed that a conversation is in progress. When answering the new call the secretary can give this information to the calling party. The new call can be parked by the secretary. Should it be more convenient for the caller, the secretary can ask the executive to call back when he becomes free.

Effective telephone attendance is also a good help to the operators, as calls put through by them are quickly answered. For the caller this means improved service and reduced telephone costs on long distance calls. System *DYA 111* also provides the user with a discreet and undisturbing telephone arrangement which can be suited to individual requirements.

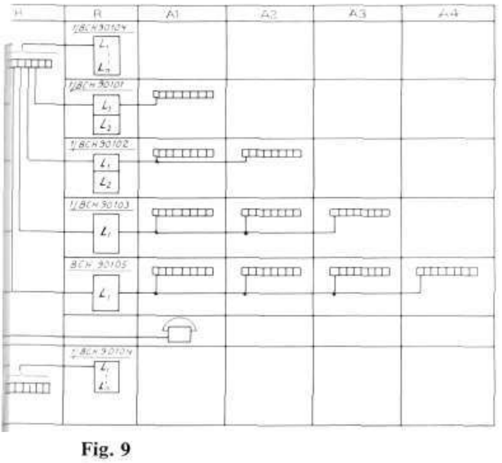

Fig. 9

Relay sets, combination facilities

H Subscriber's main station
R Relay sets
A 1-4 Extensions 1—4

The Introduction of a New Maintenance Method into the Telephone Area of Rotterdam and Its Influence on the Maintenance Organization

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The article describes the organization of the maintenance service in the Rotterdam area according to the principle of controlled corrective maintenance. The author discusses the results with the new maintenance method. Finally, plans for future changes and refinements in the organization are drawn up.

For the handling of subscriber dialled telephone traffic, the Netherlands are divided into 22 telephone districts. Each district is subdivided into a maximum of 10 sectors, each sector containing a maximum of 10 local areas.

District centres are usually located in the provincial capital, or in an important business or traffic junction in the centre of the district. Sector exchanges are usually located in the centre of the sector. Local exchanges are spread out around the sector exchange. Fig. 1 gives an overall picture of the Rotterdam district. At the top the local exchanges of the city of Rotterdam are shown, stating their present capacity and type. The main drawing shows

Fig. 1
Suvery of the Rotterdam district

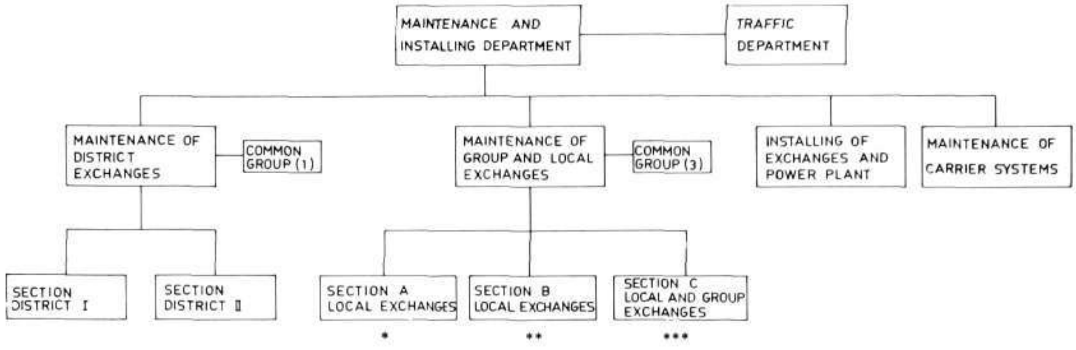


Fig. 2

Organization of maintenance and installing department

*Centrum A (20) Centrum B (22) Schiebroek (12) Terbregge (4) Waalhaven (5) Lombardijen (9) Hoogvliet (6) **West (20) Noord (19) Zuid (19) Schiedam (9) Spaanse Polder (7) ***Dordrecht (17) Zwijndrecht (10) Vlaardingen (8) Gouda (20) Gorinchem (7) Middelharnis (3) Spijkenisse (8) Oud-Beyerland (3) Sliedrecht (5)

the sector and terminal exchanges of the entire district. A telephone district can be said to consist of two parts, one administrative and one operational. In the Rotterdam district these two parts cover the identical geographical area, but in some other districts several operational districts have been joined together to form only one administrative district. Thus the 22 operational districts form only 13 administrative districts.

Most of the telephone exchanges in the Rotterdam district contain L M Ericsson equipment, viz:

- district centre *ARM 10* Rotterdam
- major sector centres *ARM 20* Gouda, Dordrecht, Sliedrecht, Spijkenisse
- minor sector centres *ARK* Oud-Beijerland, Middelharnis
- major local exchanges *AGF* with *ARF 90* bypath equipment and *ARF 10*
- terminal exchanges *ARK* and *ARF 10*

The city of Rotterdam contains at present two transit exchanges, viz Centrum and Zuid, used for the concentration of junction line traffic. These transit exchanges are built up with switching stages of type *ARF 10*. The sector exchange Gorinchem as well as a number of terminal exchanges are still equipped with *S&H* material. The Gorinchem exchange will be replaced by an *ARM 20* system in 1970. The sector exchanges of Oud-Beijerland and Middelharnis will also be changed to sector-exchanges of type *ARM 20*. Should existing buildings housing local exchanges prove to be too small to accommodate future extensions (*S&H* and *ARK*), the new exchange buildings will then consistently be equipped with *ARF 10* exchanges.

Maintenance Areas within the Rotterdam District

The sector exchanges, all exchanges within the city of Rotterdam and the local exchange of Zwijndrecht are staffed with maintenance personnel. The number of maintenance areas is evident from fig. 2. The number of persons required at present is shown in brackets. The organization is based on a division by area instead of by operational functions.

The new maintenance method was introduced in April 1966 in the following areas:

- Dordrecht, containing:
  1- local exchange *ARF 10* with 14,000 subscribers
  1- major sector centre *ARM 20* with 800 lines in and 800 lines out
  2- line concentrators *AKL* with 400 subscribers
- Zwijndrecht, containing:
  1- local exchange *ARF 10* with 5,000 subscribers
  2- unattended terminal exchanges *ARF 10* with a total of 7,400 subscribers
  10- unattended terminal exchanges *S&H* with a total of 8,200 subscribers

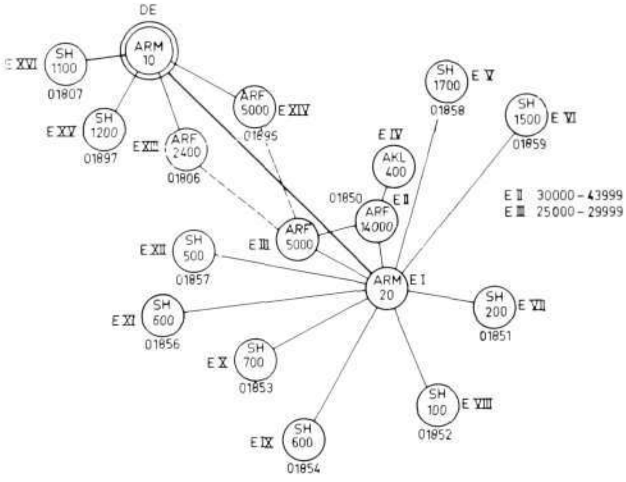


Fig. 3
Maintenance areas Dordrecht and Zwijndrecht

The maintenance method is described in the L M Ericsson manuals for the maintenance of systems *ARF 10* and *ARM 20*. The maintenance areas of Dordrecht and Zwijndrecht are shown in fig. 3. The guiding rule for the application of the new maintenance method is the balancing of the amount of maintenance work against the functional quality of the telephone traffic. The technical aids which are available today for the determination of the quality of traffic in the maintenance areas of Dordrecht and Zwijndrecht are described in fig. 4. The rooms housing the switching equipment are only entered when a fault has been indicated by the quality control equipment or upon receipt of subscriber complaints. The quality control equipment is never installed in the same room as the switching equipment. It should be evident that the new maintenance method can only be applied in exchanges of L M Ericsson manufacture, types *ARF* and *ARM*. Exchanges of type *AGF* and *S&H* still require preventive maintenance routines for the machine-driven and step-to-step selectors respectively.

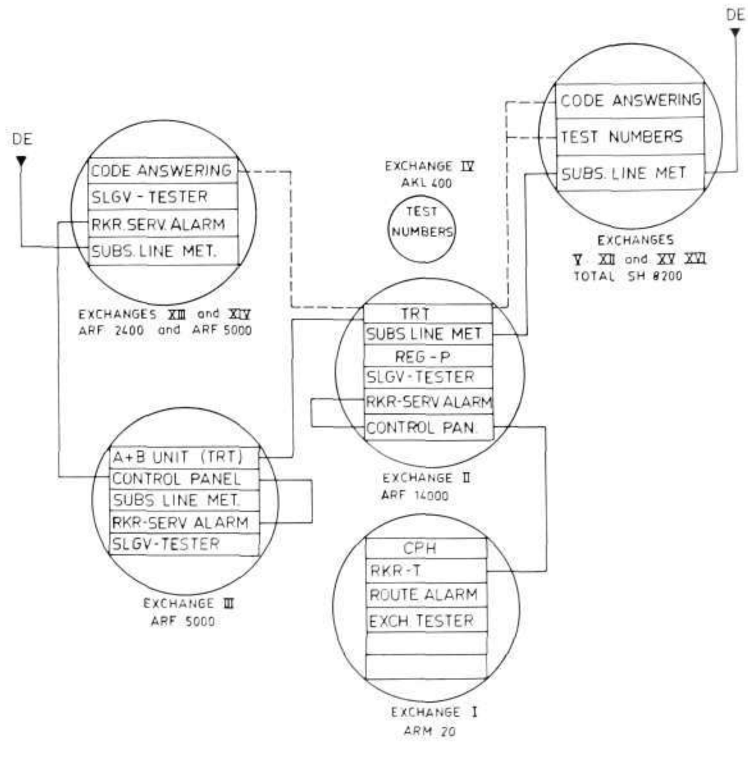


Fig. 4
Equipment for supervision and fault-tracing

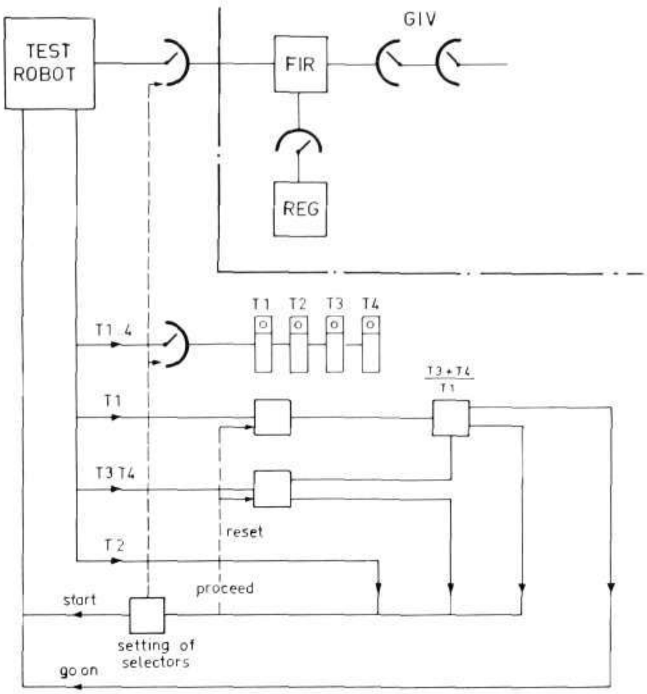


Fig. 5

Determination of traffic quality, district exchange I

T1 Total number of calls
T2 Digit "5" received
T3 Answer not received
T4 Clearing signal not received

The maintenance results obtained in the above mentioned areas proved to be so satisfactory that it was decided on the first of January 1967 to introduce this system in all areas which disposed over a traffic route tester, viz. Gouda, Spijkenisse and Vlaardingen.

During the second half of 1967 controlled corrective maintenance was introduced on a limited scale also in the *ARF* local exchanges of Terbregge, Schiebroek II, Waalhaven, Spaanse Polder, Lombardijen, Hoogvliet, Centrum IV as well as in the maintenance area of Sliedrecht. In these exchanges an *SL-GV* tester is utilised. In order to enable the determination of the traffic quality in *AGF* exchanges as well, the existing statistics-providing equipment is being improved and enlarged upon, i.a. by means of transmission test equipment.

The maintenance areas containing type *ARK* exchanges and the area of Gorinchem have been provided with test robots. These robots are of the less comprehensive type, as, because of future equipment changes, large investments would be unwarranted.

An investigation is being conducted into the possibilities of introducing a simple means of call rotation in *ARK* local calls, as this is necessary in order to implement controlled corrective maintenance correctly.

For the determination of the quality of traffic via district exchange I (*ARM 10*) a switch was designed to which the existing exchange testers can be connected. See fig. 5. Two switches can test 18 groups of registers and a further 5 switches have a capacity of 9 groups of registers. In order to prevent undue subscriber irritation a test is stopped when digit "5" is not received from the automatic answering test subscriber. A quotient determination is carried out on a separate counter, $(T3 + T4)/T1$. After 750 test connections it is decided whether to terminate the test, to carry on, or to change to fault tracing, all in accordance with the sequence nomogram. If it is decided to continue the test, a further determination is made after 250 additional connections. Tests can thus be carried on to a total of 1,750 connections. In this manner it is possible to test during a weekend all registers for one type of traffic.

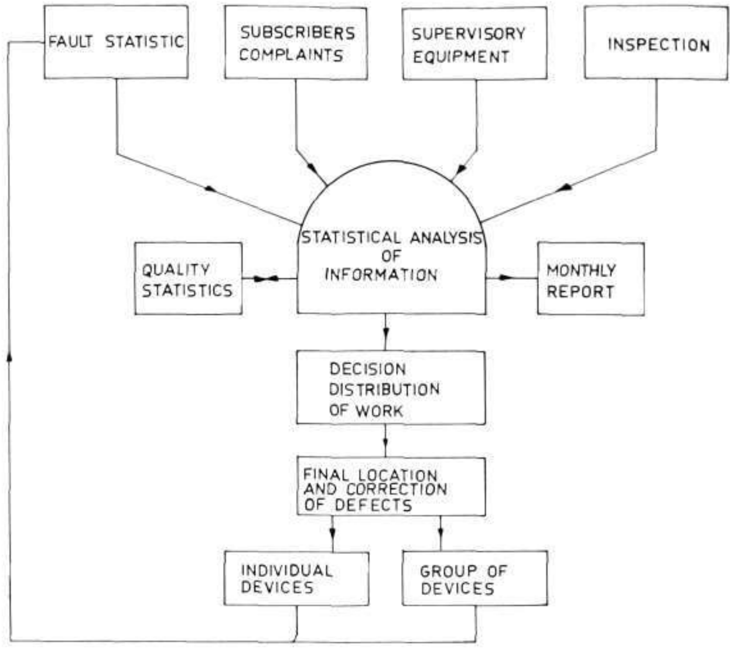


Fig. 6
Collection and analysis of information

The Functioning of the New Maintenance Method

The different types of work are roughly shown in fig. 6. There are mainly four sources which cause work to be started in a telephone exchange:

- quality determining equipment
- subscriber complaints
- staff observations
- disturbance statistics, (fault statistics) and quality statistics

In a local exchange, the principal sources will be the subscriber complaints (usually related to the individual subscriber circuitry) and the data obtained by means of quality determining equipment such as the traffic route tester. In sector exchanges, the principal sources are the various types of quality determining equipment (centralograph and traffic route tester). Faults reported by other exchanges are usually the result of quality determination in those other exchanges by means of the traffic route tester or the *SL-GV* tester.

It is of great importance that the work indicating sources provide really reliable information. At present the subscriber complaints for the entire district terminate in one central point, "special services 007", where they are divided into two groups. One group covers those faults which presumably have their origin in the local network or in the subscriber's own equipment, the other group containing exchange faults, including main distribution frame. This last group of complaints is directly forwarded to the maintenance area concerned. The aim is to operate an organization as shown in fig. 7. Complaints which presumably relate to exchange faults, are shown to be forwarded directly to the national maintenance centre (*NMC*) at the district exchange.

The *NMC* also contains the quality determining equipment for the district exchange, the congestion meters for the outgoing long distance routes (inter-district traffic) and for the outgoing junction lines within the district itself. In many instances, e.g. complaints of congestion, the *NMC* can thus provide the subscriber with an immediate and satisfactory answer. In addition hereto complaints regarding a specific type of traffic can be systematically gathered, thereby enabling a faster identification of the fault. Only when it can be

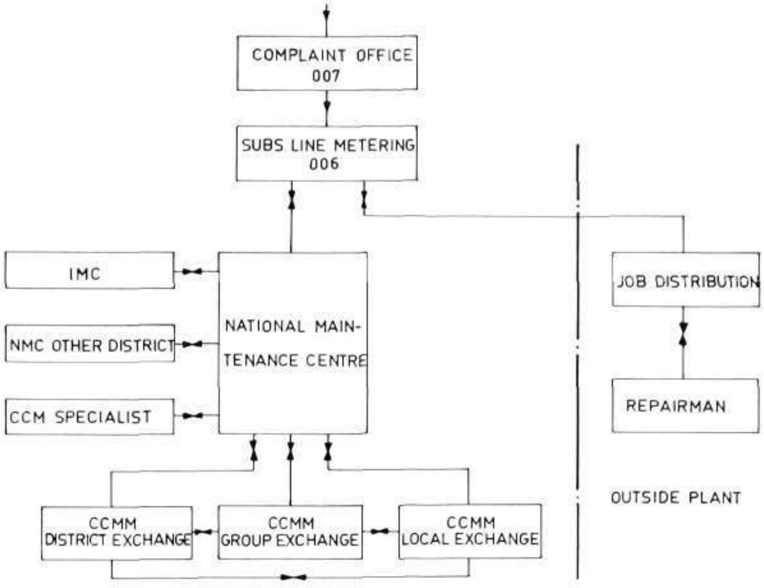


Fig. 7
Organization for controlled corrective maintenance

assumed that the cause of the fault is to be found in one of the local or sector exchanges, is the complaint passed on. The maintenance man receiving this complaint, is also engaged in the collecting of the traffic quality data of that exchange (*CCMM*). The *NMC* must be staffed with a person who knows all systems in use in the district and who has a thorough knowledge of the various signalling methods. He must be able to converse intelligently with the *CCMM* in the maintenance areas, being either the local maintenance manager or in larger areas the assistant maintenance manager. The *NMC* also keeps in touch with the trunk maintenance centre of the district (*IMC*), with the *NMC*'s in other districts and with the *CCM*-specialist forming part of the COMMON-GROUP placed at the disposal of the maintenance manager.

The *CCMM*s inform each other about the results of quality tests made of the traffic between various sector and local exchanges. It is of great importance that they have access to abundant technical information on the quality determining equipment available in the district.

One of the major tasks when introducing controlled corrective maintenance is the correct programming of the traffic route tester and the *SL-GV* tester.

from \ to	25	26/27	28/29	30/31	32/33	34/35	36/37	38/39	40/41	42/43	1851 1852 1853	1854 1857	1858 1859	Gd Mdh 1856	Asd Gv 1856
/25		2													
26/27			8											9	
28/29	20			14											
30/31			13		1										
32/33						4					6				
34/35							7							15	
36/37								10							23*
38/39									16						
40/41										19					
42/43				22											
1851 1852 1853					17							3		21	
1854 1857													11		12*
1858 1859		5									18				

Fig. 8
Traffic route survey, Dordrecht, since July 1, 1967

*** Day and night**

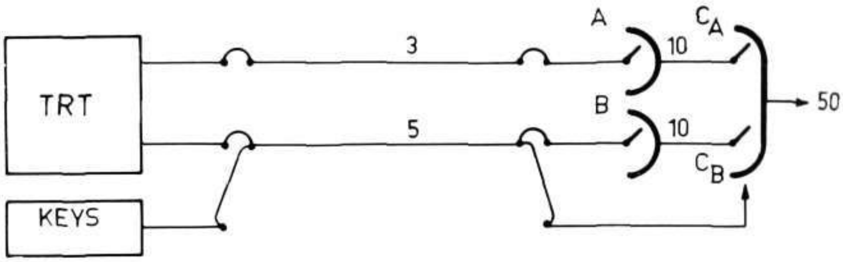


Fig. 9
C-selector for A—B unit

Fig. 8 shows how the traffic route tester in Dordrecht is programmed. This traffic route tester tests the traffic in the local exchanges Dordrecht and Zwijndrecht, the junction line traffic between these two exchanges, the sector traffic as well as the interdistrict trunk traffic. At the beginning of 1968 $A + B$ units will be installed in the Amsterdam and the Hague local exchanges, as the traffic in those directions reaches Dordrecht directly and does not pass over the district exchange.

The *ARF* exchanges contain 1 test number for every 200 subscribers. In the Zwijndrecht local exchange an $A + B$ unit has been installed and the local traffic is tested with programs 2, 8 and 20. The local traffic of the Dordrecht exchange is tested with programs 1, 4, 7, 10, 16, 19 and 22. The traffic between these local exchanges is covered by programs 13 and 14. In order to observe the traffic from and to the terminal exchanges, a test number has been wired back to the traffic route tester. This enables the testing of the traffic from these exchanges to Dordrecht local (17) and to Zwijndrecht (5) as well as the traffic in the opposite direction with programs 6 and 9 respectively. The traffic between terminal exchanges can be tested with programs 3, 11 and 18. The traffic towards other sector exchanges such as Gouda (entirely *MFC*-traffic) and Middelharnis (DC impulsing from the district centre) is tested for each exchange type with programs 9, 15 and 21.

The programs passing those exchanges which are not equipped with call rotation (for example terminal exchanges of *S&H* type) must preferably be run during day time in order to cover major parts of the switching equipment. Other programs are best run through during night time or over weekends as congestion is hardly encountered then. The programs must, however, also be run occasionally during busy hours, in order to determine the overall traffic quality.

In order to improve the testing procedures with the traffic route tester, the $A + B$ unit in unattended exchanges of more than 2,000 subscribers will be augmented by a *C*-switch (Fig. 9). The signals for the setting of the C_A and C_B switches are sent over the same signalling wires that are used for the setting of the *B*-switch but during the intervals when this switch is at rest. The setting will be carried out by means of a push button key sender.

As long as it is necessary to utilize the *SL-GV* tester for quality determination in unattended exchanges a simple form of $A + B$ switch must be used for the remote switching of *A* and *B* test numbers as well as of the *SL-GV* switches. It is necessary to make an intelligent choice of test numbers and programs.

Both the traffic route tester and the *SL-GV* tester must incorporate a circuit which prevents subscribers from being disturbed by wrong connections during night time testing.

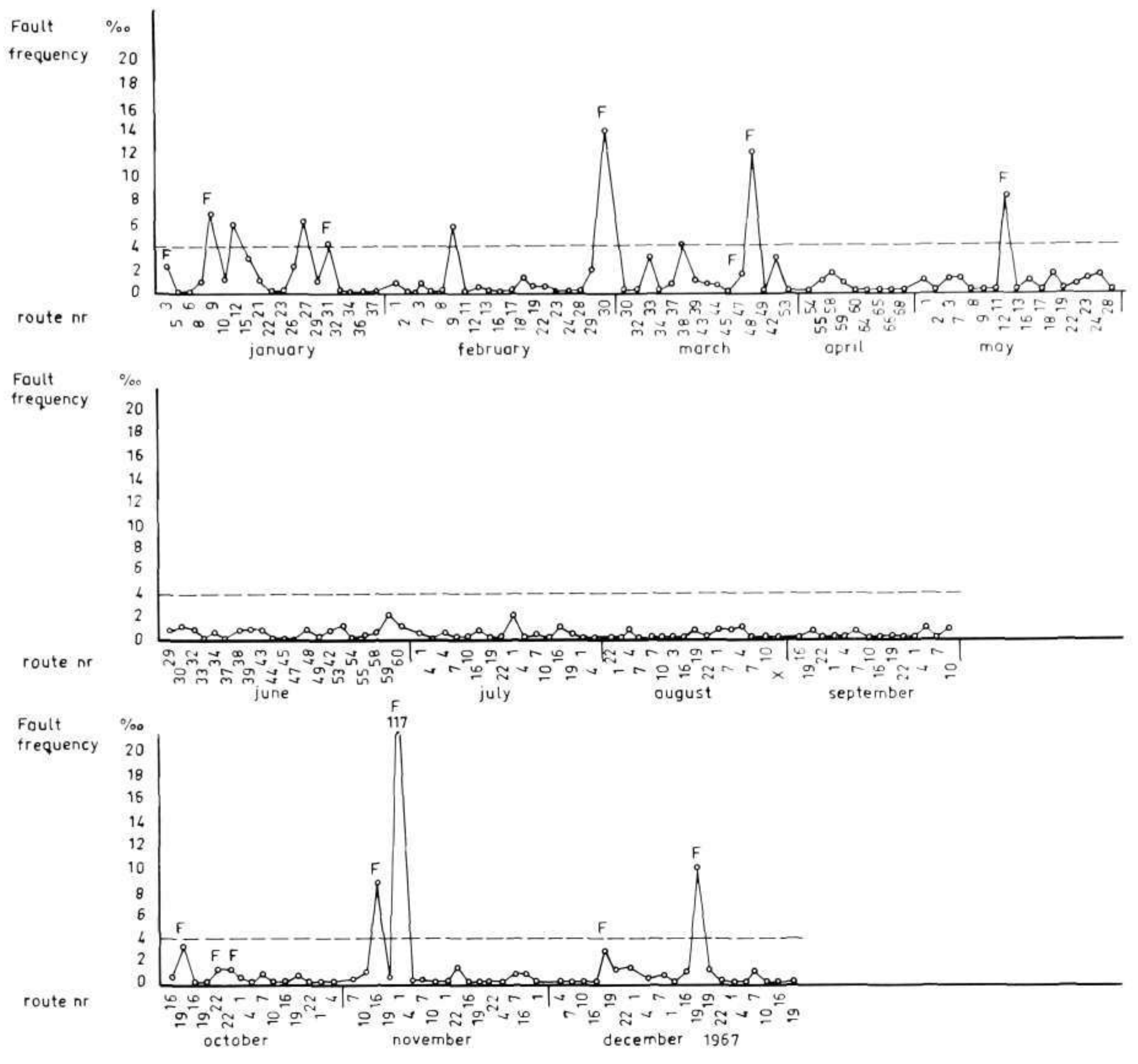


Fig. 10

Results of TRT-tests, Dordrecht local exchange

F Fault found

The results obtained from the traffic route tester must be studied accurately and all circumstances surrounding the tests must be kept account of. Fig. 10 shows the results of the traffic route tests of the Dordrecht local traffic during 1967. For this year the test limits in the sequential test diagram were set at 0.2–0.6 %, provided the results did not clearly indicate an individual fault, the location of which would be warranted even with a lower fault percentage. It should be kept in mind that the exchange is attended and that consequently the day programs are stopped whenever the fault percentage becomes so high that the diagram stipulates fault location. This occurred in 10 instances, the results of which are not described here. It is clear that neither night programs nor weekend programs are stopped for fault location purposes. The results for the months January to September would indicate that with the fault percentage allowed, a test of the local traffic once every 2 months would be sufficient. During the months of October, November and December a disproportionately high number of faults occurred, but during those months extensions and alterations were carried out causing most of the faults.

Fig. 11 shows the results of the traffic route tester when connected to the local traffic of the Zwijndrecht exchange, whilst fig. 12 shows those of the local traffic in the unattended Ridderkerk exchange, when using the *SL-GV*

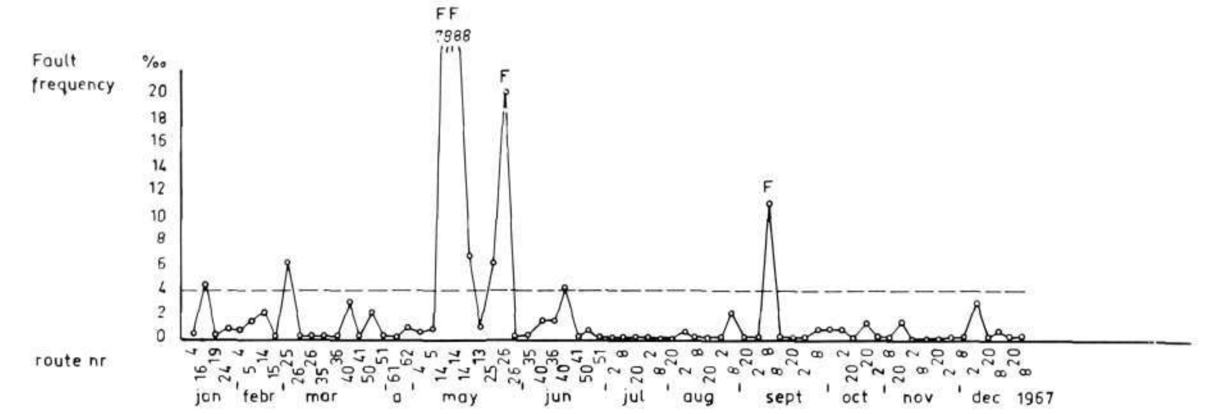


Fig. 11
Results of TRT-tests, Zwijndrecht city exchange
F Fault found

tester. The results for Ridderkerk compare badly, but here an extension with 2,000 subscribers was installed during April and May. The necessity of carrying out the majority of tests on junction line traffic rather than on local traffic is evident from the results shown in figures 13 and 14 which cover the Ridderkerk district traffic (*SL-GV* tester) and the Dordrecht sector traffic (traffic route tester). It is therefore intended to pay more attention to junction line traffic testing during 1968.

The Dordrecht sector traffic attained an excellent quality towards the end of the year. The bad results in the beginning of the year and during the summer months were mainly the result of work carried out in the local exchanges.

The rather complicated network structure of the Rotterdam junction line traffic results in the programming of the traffic route testers in the local exchanges becoming especially difficult. During 1968 a test will be carried out in order to determine the "capacity" of a traffic route tester in the Rotterdam

Fig. 12
Results of SL-GV-tests, Ridderkerk local exchange
F Fault found

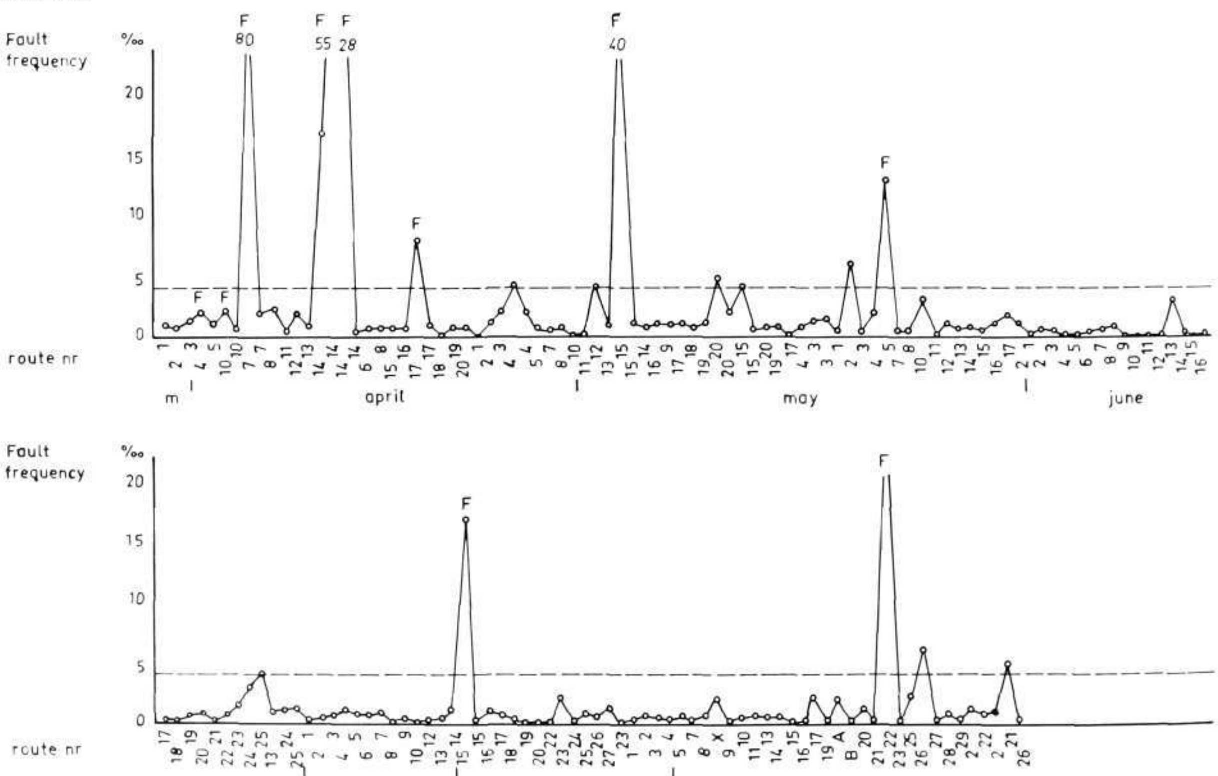
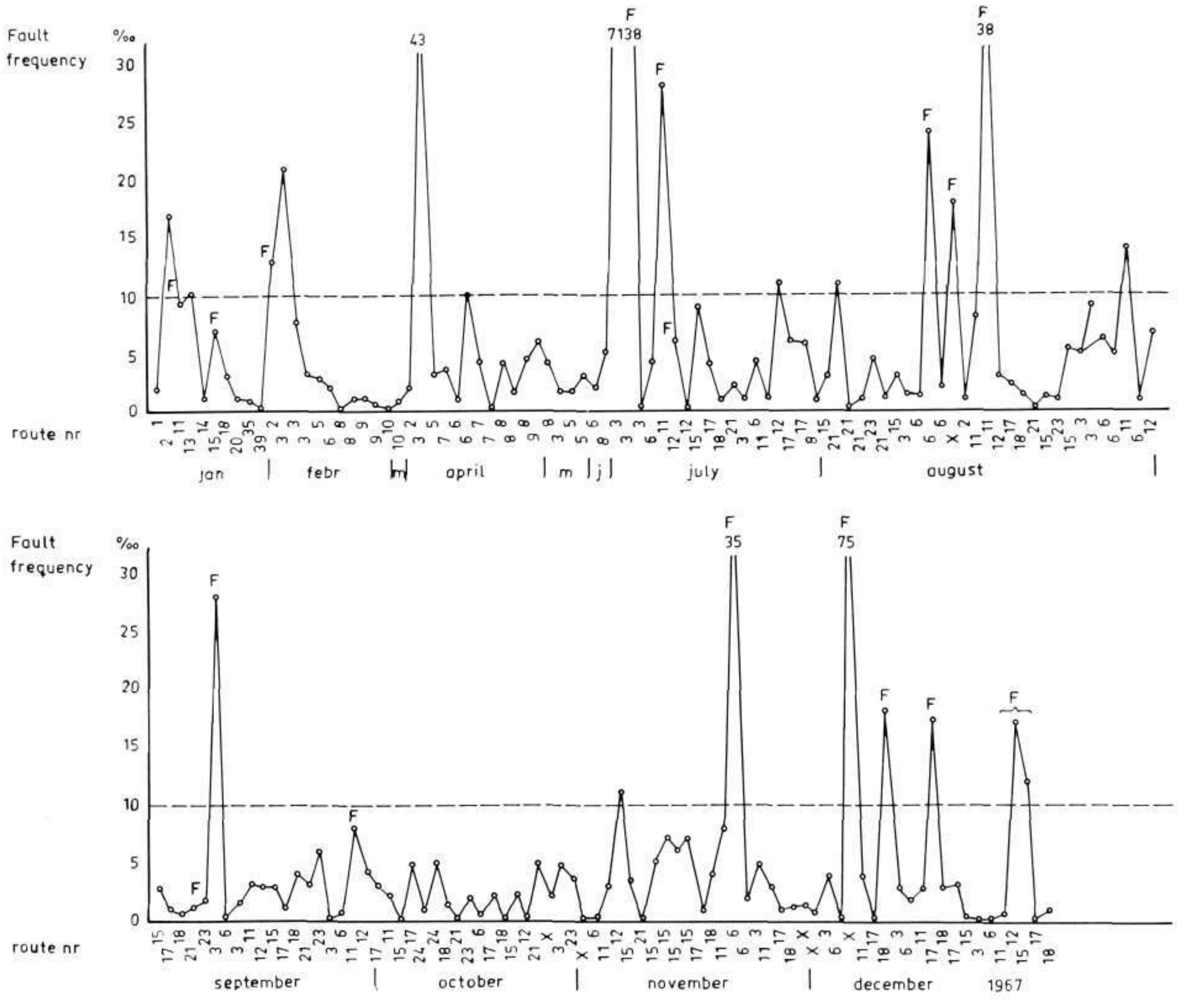


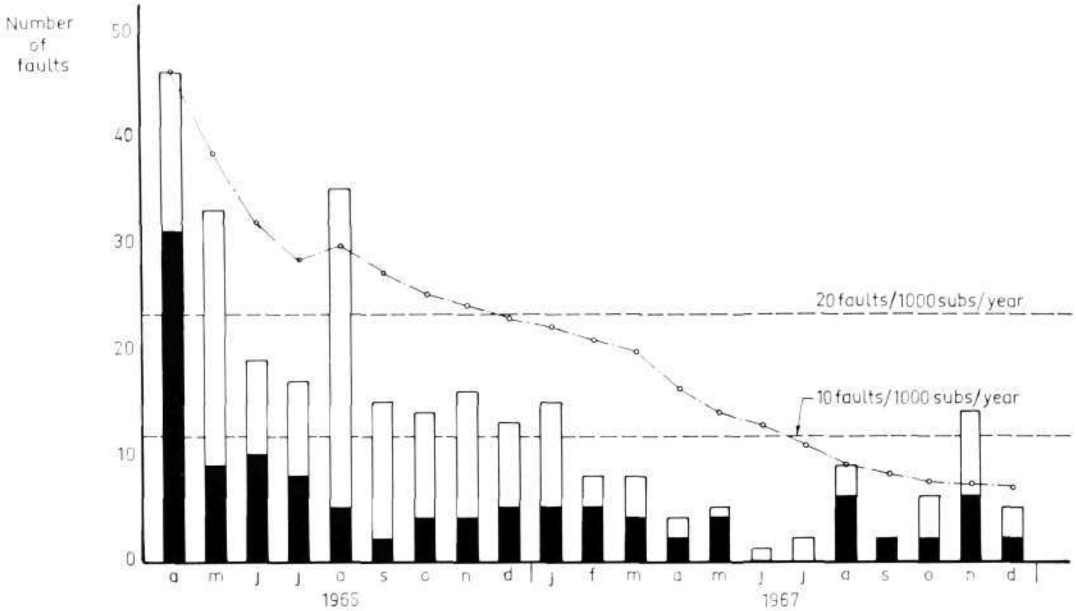
Fig. 13
Results of SL-GV-tests, Ridderkerk districts traffic

network. For this purpose a traffic route tester has been installed in the Zuid local exchange (*AGF* 20,000 subscribers) and its $A + B$ units have been connected to the local exchanges of Hoogvliet (*ARF* 10,000 subscribers), Waalhaven (*ARF* 6,000 subscribers) and Lombardijen (*ARF* 16,000 subscribers). This "capacity" is dependant upon the network structure as well as upon the desired fault limit, i.e. the sequence diagram used for the different types of traffic.

The staff observations do not form a major source for the determination of the traffic quality, but are a valuable aid towards it. The staff must be trained to analyze each fault found and to check whether such fault may reoccur in other equipment. When the exchanges are entered for checking purposes it is important to listen to the rhythm of the switching operations.

Fig. 14
Results of TRT-tests, Dordrecht sector traffic
F Fault found





	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Subscribers	31	9	10	8	5	2	4	4	5	5	5	4	2	4	–	–	6	2	2	6	2
TRT	7	5	–	2	2	1	4	6	5	6	–	3	–	1	–	–	1	–	3	8	3
REG-P	2	5	1	1	7	4	3	1	–	1	2	–	–	–	1	1	–	–	–	–	–
RKR	–	1	3	–	2	2	–	–	1	–	1	–	–	–	–	1	–	–	–	–	–
general alarm	1	4	1	1	2	2	2	1	–	–	–	1	1	–	–	–	–	–	–	–	–
DL	–	–	2	1	4	2	–	4	2	1	–	–	1	–	–	–	–	–	–	–	–
pers	5	9	2	4	13	2	1	–	–	2	–	–	–	–	–	–	2	–	1	–	–

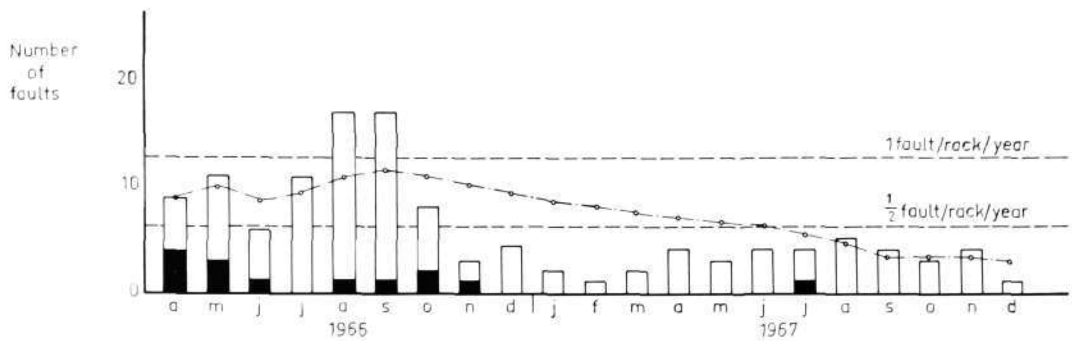
Fig. 15
Fault statistics, Dordrecht local exchange

Reported by subscribers
Other origins
Progressive average

A disturbance in this rhythm must be acted upon by the staff. The staff must critically evaluate those results which originate from other sources than the quality determining equipment such as statistics counters. Therefore, a proper training of the staff is of the utmost importance. After having passed the trade school (general educational) and having been attached to the maintenance organization, the staff must be put to work in the inspection team, the installation team and the testing team. Only hereafter is the staff put to work in a telephone exchange, with emphasis being given to the working methods necessary for the new method of maintenance.

The statistics on disturbances which are being compiled locally at the maintenance centre should be uncomplicated. This is necessary, first of all for the fast information of the maintenance personnel in the maintenance area about the weak points in the equipment, requiring special attention, and secondly for the information of the installation staff about the possibilities they have to improve the quality of their work.

Fig. 16
Fault statistics, Dordrecht sector exchange



	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
Subscribers	4	3	1	–	1	1	2	1	–	–	–	–	–	–	–	1	–	–	–	–	–
TRT	–	1	1	7	1	–	–	–	1	–	–	–	–	–	–	–	2	–	–	–	–
CPH	2	2	–	2	3	3	2	2	2	2	1	1	1	3	2	1	1	2	1	3	1
general alarm	1	1	–	–	1	1	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–
DL	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
pers	3	2	2	1	6	7	–	–	–	–	–	–	–	–	–	1	1	1	1	–	–
other exchanges	–	2	2	1	4	4	2	–	1	–	–	1	2	–	2	1	1	1	–	1	–
miscellaneous	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–

		miscellaneous	LR	REG-L	FBX	SR	LKR	SLA/B/C/D	SSA-SSB	KSR	SLM	GVA/B	RSM RSV	CD-KMR	GVM	GV-KMR	TRY	AKL	FIR-LI	FUR-LN	RP	DF	SUB-TOTAL	TOTAL
RELAYS	ADJUSTMENT		7	26	2	3	4	6	2	4	2		2	2	1						1		62	
	INSULATION OF CONTACTS		3		2	2												1					8	
	COILS		1	1							1					1		1					5	
	STICKING OF ARMATURES		1	5		1																	7	
	SPLITTERS IN SPRINGSETS		5	5		5	1			1	1	1		3		2		1					25	
	WIRING, contacts		3	5	1	3	5	1		2	1	2	1	1		5		1					31	
	WIRING, not soldered		3	4		2	1		1		2		1										14	
	MISCELLANEOUS		6	1	1	2										4	1	1					16	168
CROS BAR SW	ADJUSTMENT OF HOR BARS																						-	
	" OF SEL FINGERS							2				1											3	
	" OF VERT BARS							1					1										2	
	" OF CONTACTS							4				1											5	
	COILS											2											2	
	WIRING			1				6	2			3	1										13	
	BROKEN PIVOTS							11				3											14	
	NOT FASTENED PIVOTS							4				2	1										7	
	HOR. AND VERT. SPRINGSETS			1				1				3											5	51
GENERAL	CABLING	1	1			1		3				1							1			8	16	
	RECTIFIERS			2							2							1					5	
	RESISTORS		1				3			1								1					6	
	CAPACITORS			1																			1	
	METERS		4																				4	
	PLUGGING		9	1		8	2	1					1					2					24	
	ELECTRON TUBES														7								7	
	KEYS AND JACKS																						-	
	CAPACITORS, wiring torned															3							3	
	FAULT IN DESIGN	1		1																			2	68
	TOTAL	2	44	54	6	27	16	40	5	8	9	19	8	6	8	15	1	9	1	-	1	8		287

Fig. 17
Fault statistics, Dordrecht ARF 10, April 2 1966—December 31 1967

Figures 15 and 16 show the fault statistics for the local and sector exchange Dordrecht since the time of putting into service. They give a clear picture of the results obtainable with the new maintenance method.

By inserting the values of the world statistics published by L M Ericsson (10 to 20 faults per 1,000 subscribers and year for *ARF* exchanges, and 1/2 to 1 fault per rack and year for *ARM* exchanges) a comparison can be made as regards the quality of the different exchanges. The increase in the number of faults after October 1967 was caused by installation and alteration activities.

The statistics of figures 17 and 18 serve to determine weak points in components. They are of great value during discussions with the manufacturer regarding improvements in component quality. They also serve as basis for test reports during discussions with the installation department or with the installation staff of the manufacturer. They point out to the maintenance personnel the specific weak points which are to be kept in mind during fault

		TB	REG-H	REG-E	M	KM	DF	FIR-ZL-H	FIR-ZL-KE	FIR-SC-N	FIR-ZL-HE	FUR-SC-N	FUR-SC-NK	FUR-L-H	FUR-L-KE	FUR-ZT-F	GI-GU	TIG	HYBRIDS	RSM	SUB-TOTAL	TOTAL
RELAYS	ADJUSTMENT	1	5		1	1		3		6			1			1				1	20	
	INSULATION OF CONTACTS		1		1	2				3											7	
	COILS		1	1						4		1									7	
	STICKING OF ARMATURES					1		1		1											3	
	SPLITTERS IN SPRINGSETS		1					5	1	3	3									1	14	
	WIRING, contacts		3					1	1	2					1	1					9	
	WIRING, not soldered		3	1				1		1							1			1	8	
	MISCELLANEOUS					1		1										1			3	71
CROS BAR SW	ADJUSTMENT OF HOR BARS																				-	
	" OF SEL. FINGERS		1														6				7	
	" OF VERT BARS																				-	
	" OF CONTACTS																1				1	
	COILS																1				1	
	WIRING																2				2	
	BROKEN PIVOTS																				-	
	NOT FASTENED PIVOTS																1				1	
	HOR. AND VERT. SPRINGSETS																				-	12
GENERAL	CABLING				1		3								1		7				12	
	RECTIFIERS								2		1										3	
	RESISTORS									1						1					2	
	CAPACITORS					10															10	
	METERS				2				1												3	
	PLUGGING																		2		2	
	ROA'S		2																		2	
	KEYS AND JACKS																				-	
	FAULT IN DESIGN			1																	1	
	MISCELLANEOUS				1												1				2	37
	TOTAL	1	17	3	6	15	3	12	5	21	4	1	1	-	2	3	20	1	2	3		120

Fig. 18
Fault statistics, Dordrecht ARM 20, April 2 1966—December 31 1967

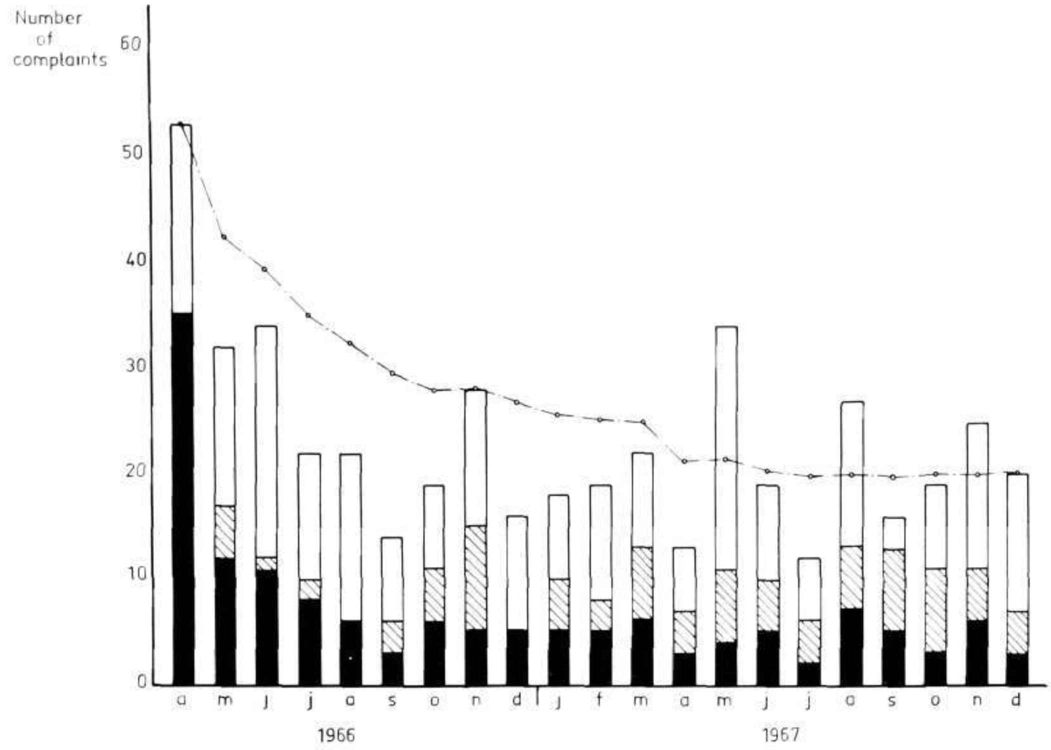


Fig. 19
Subscriber complaints, Dordrecht

Fault found in own exchange or on MDF
Fault found in other exchanges
No fault found
Progressive average

tracing. Fig. 19 represents a survey of subscriber complaints, the causes of which were most probably to be found in the telephone exchange. This type of graph also gives an indication of the overall quality of an exchange, provided the progressive average is used. Some graphs indicate seasonal fluctuations (such as faulty coils in *ARK* terminal exchanges, some show outside interference).

Plans for the Future

Fig. 20 shows the present size of the staff in the Dordrecht maintenance area. The exchange work proper, the control centre, the administrative tasks for the maintenance area (subscriber registration, number allocation etc.), as well as simple maintenance of power plant and stand-by power plant require 4 persons. Two persons attend to the normal *MDF* work. The assistent is only required because of the present work on central additions and alterations. There exists a certain amount of spare time which is partly offset by the running of refresher courses. Even increasing the present capacity of the sector exchange to 2,000 lines in and 2,000 lines out and of the local exchange to 30,000 subscriber lines, would, with the today attained quality, not necessitate an increase in the staff. This shows the importance of a correct dimensioning of maintenance areas in the future.

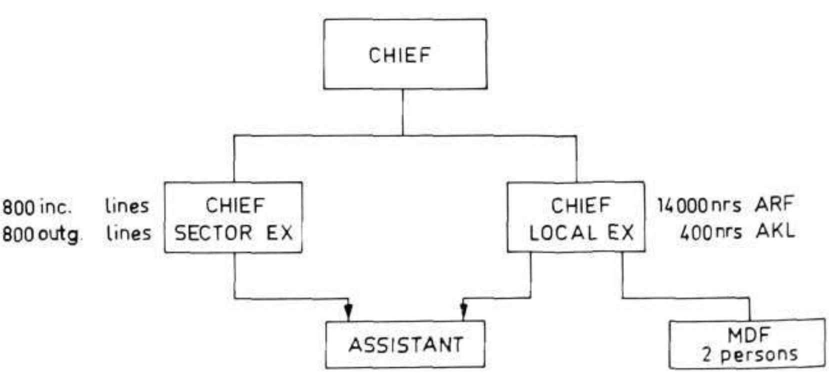
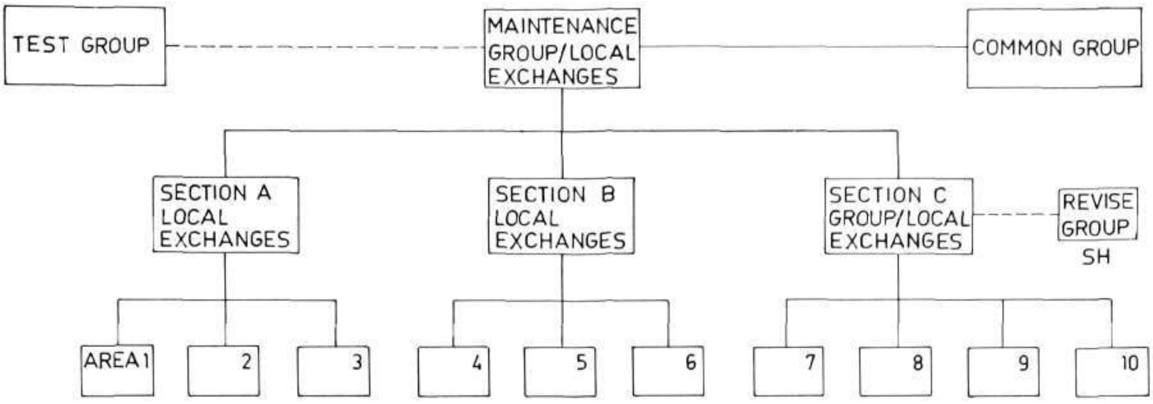


Fig. 20
Organization of the Dordrecht area



Areas 1....6: Local exchanges with a total capacity from 50,000 to 100,000 numbers

Areas 7....10: 2....3 group exchanges and several local exchanges with a total capacity from 20,000 to 50,000 numbers

Fig. 21
Future organization

These maintenance areas should not contain more persons than those absolutely necessary for the maintenance work. During periods of large quantities of special work, such as the testing of additions to exchanges, or of new exchanges, it ought to be possible to draw personnel from a central group of staff. The same applies to difficult faults, the location of which requires special testing apparatus, and the staff for which should be supplied from a common group of personnel, thus ensuring efficient working procedures. When planning a new organization attention should be paid to the educational facilities of young staff members as well as to the necessary job rotation of managers.

Another important aspect is the attaching of one or several *CCM*-specialists to the common group. Their tasks consist of the coordination of results, the formulation of guiding rules, the consolidation of the results obtained from various maintenance areas, the drawing up of the regulations for the new maintenance method and the designing of the required auxiliary equipment. The common group can also contain one or several circuitry experts, which attend to principal faults in the circuitry design, as well as a general assistant, who is responsible for the administrative part of alteration jobs, and is in control of the mobile cleaning units for the terminal exchanges.

The organization planned here, is shown in fig. 21. The local maintenance areas would contain exchanges up to a maximum of 50,000 or 100,000 subscribers, would contain a common maintenance centre with 2 or 3 traffic route testers and could become established as soon as the *AGF* exchanges in an area had been replaced by *ARF* exchanges. The staff required, would vary between 12 and 20, including *MDF* personnel.

The maintenance areas falling under section *C* ought to be concentrated also, forming areas with at least 2 sector exchanges and a number of local exchanges with a capacity of 20,000 to 50,000 subscribers. An attended sector would contain one or two traffic route testers, whilst in an unattended sector exchange the results would be transferred by the remotely controlled traffic route tester by means of data transmission to the attended sector exchange. The staff would vary between 5 and 15 persons. A redesigning team would be attached to the section in order to make the necessary changes in the *S&H* equipment. In order to be able to establish these maintenance areas it would be absolutely necessary to dispose over good means of transportation.

Final Remarks

Based on the good results obtained with the new maintenance method in the Dordrecht and Zwijndrecht areas, the central directorate of the *PTT* have decided to introduce this method in all applicable areas.

When developing this method still further, efforts must be concentrated on the faster location of faults in the trunk traffic and the mechanized treatment of data.

As similar new maintenance methods have also been introduced in other countries, it would be of utmost value to arrive at a mutual exchange of data compiled on the same basis.

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Some Economic Aspects on the Long-Term Planning of Telephone Networks
Part I

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Like other public utilities the operation of a telephone plant involves considerable long-term investments. It is therefore of particular importance to carry out development planning and economic selection studies before decisions are made. The undertaking of investments, without a long-term plan, may lead to serious errors and heavy financial losses.

The provision of the necessary data for the layout of local and trunk networks, however, often requires such extensive numerical calculations that they can hardly be dealt with satisfactorily by manual means.

Therefore, in order to simplify the calculation and shorten the time necessary for planning, L M Ericsson have developed methods which permit programming of the most laborious operations for an electronic computer. During the last few years L M Ericsson have assisted many administrations all over the world to establish plans for extension of telephone exchanges and local and trunk networks, thus helping them to obtain a solid basis for their decisions.

The planning of local and trunk networks is essentially a routing problem. Besides this routing problem attention must be paid to the choice of system, the numbering scheme, the charging plan, the transmission and signalling limits and, of course, the available capital.

In a modern telephone switching system the routing of the traffic is not dependent on the numbering, and it is not necessary to take the tariff zones into consideration when deciding on the boundaries of numbering areas.

Thus a country may be divided into areas with regard to

- numbering areas
- routing and switching of traffic
- tariff zones.

As a general principle for any system the choice of digits to be used for the numbering plan should be kept as independent of charges and routing as practicable without making routing and charging equipment too complicated. Other aspects of the numbering plan are treated in great detail in the recommendations given by CCITT in its manual on National Telephone Networks and will not be dealt with in this context. In the sequel stress will be laid on questions regarding the routing of traffic in a network.

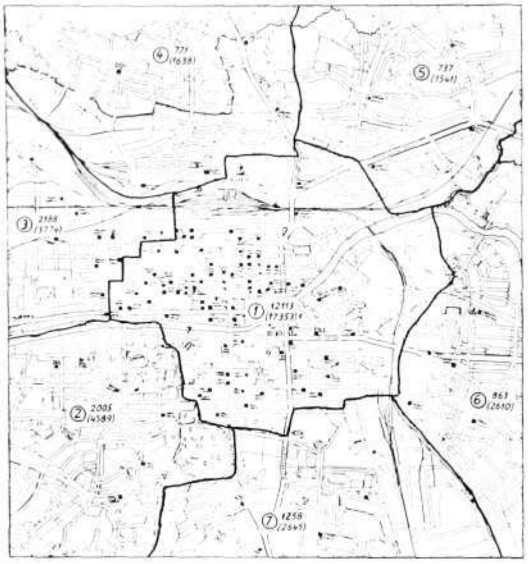


Fig. 1
Exchange locations and boundaries in a multi-exchange area

The planning of a national network should start with a division of the country into numbering areas. When making this division attention must be paid to the following factors:

- the community of interest between the exchanges
- the number of digits to be used for calls within and outside the numbering area
- existing local and junction networks
- the transmission plan.

In order to arrive at the most economical division into numbering areas it may be necessary to investigate several alternatives. The economic optimum is obtained when the present value of the costs is as small as possible.

The division of the country into tariff zones, i.e. the traffic policy, should have no effect upon the layout of the network.

Survey of Problems Encountered in Planning

Short Description of a Telephone Network

In order to define the terminology used, the following short description of a network may be of some value.

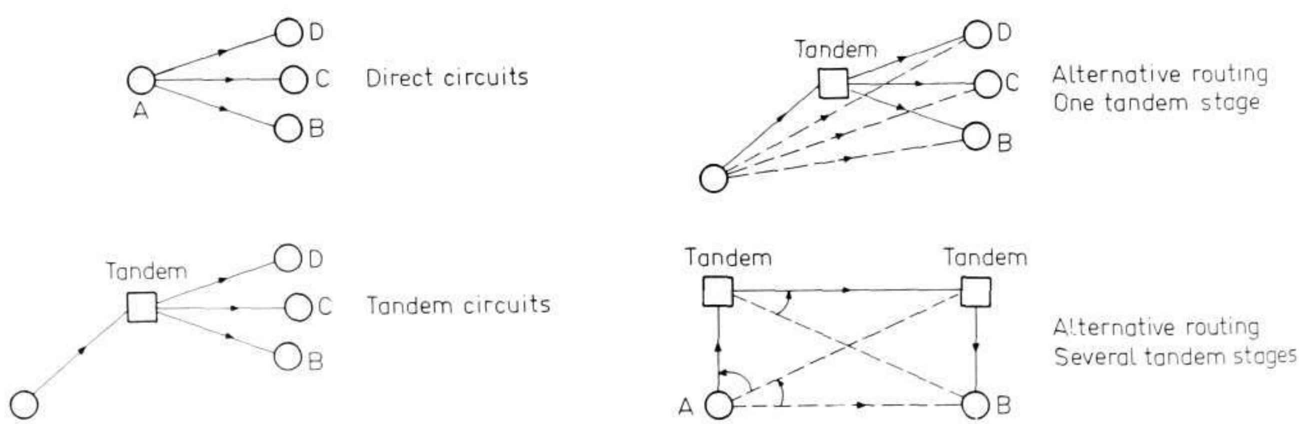
In a multi-exchange area, fig. 1, each exchange serves a certain exchange area. Within each area the subscribers are connected to the exchange by individual circuits forming *the subscriber's network*. Between the exchanges connections are established on *the junction network*, which interconnects the exchanges on common circuits according to a certain pattern.

Between the exchanges the connections can be made in different ways, fig. 2, viz.

- *direct circuits* on which the entire traffic between two exchanges is carried directly from one exchange to another
- *tandem circuits* on which the entire traffic between two exchanges is routed via one or more *tandem stages* in other exchanges
- *alternative routes*, the traffic seeking primarily a direct route called *high-usage route* and, if all circuits on the route are engaged, tandem circuits via one or more tandem stages.

Fig. 2
Direct, Tandem and Alternative routing in a junction network

A = Sending exchange
B, C, D = Receiving exchanges



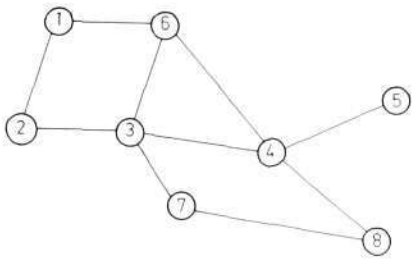


Fig. 3
Example of cable runs in a network

The circuits between the exchanges in the network are to a large extent assembled in bundles. Such bundles are called *cable runs,* see fig. 3. The cable runs define the permissible paths in the network.

The Aim and Content of the Long-Term Plan

The aim in long-term planning of local and junction networks is to provide the framework for long-term investments and to provide a check that short-term decisions are consistent with long-term objectives.

The long-term plan should cover a period of, say, 50 years for the numbering plan and 15–30 years for the equipment. *The short-term plan* generally covers a period of 2–5 years and is concrete and detailed. It must define all the material required and specify in detail the investments needed during the short-term planning period.

This paper will deal solely with questions of long-term planning, leaving problems of short-term planning for a future issue.

The most important information that should be embraced by the long-term plan for the network is the following:

- the locations of the exchanges
- the boundaries of the exchange areas
- the number of subscribers within each area
- cable runs for the junctions and principal main cables and conduit routes
- the transmission plan
- the types of cable
- the traffic flow between the exchanges
- the division into tandem areas and the routing of the traffic
- the types and number of junctions between the switching points
- the associated costs.

The study is based on:

- forecasts of subscribers within different areas and the inter-exchange traffic, local and trunk
- cost data for different kinds of circuits, physical, carrier etc.
- the transmission and signalling plan and permissible traffic losses.

All calculations aimed at determining the economic layout of a network must be based on a certain system or a co-ordinated group of systems. And to compare different systems one must seek for each the optimal combination of plant components.

Data Needed for Planning

Besides a knowledge of the existing plant the following information is necessary for the planning of a telephone network:

- forecasts
- provision cost (cost of acquiring and owning property and plant that have relatively long lives)
- expected service life, maintenance and operating costs. Rate of interest
- permissibe traffic losses. Transmission and signalling plan.

Forecasts

The making of forecasts is a difficult and hazardous operation. But as a well prepared forecast is a condition for successful and economic operation of telephone plant, it pays to have a staff specially trained in this work. The cost of making careful forecasts is generally small compared with the savings obtainable.

It is easier to make forecasts for big entities than for small.

The estimation of the number of subscribers for an area should therefore be done in the following steps:

a) Estimate of the total number of subscribers. This estimate, made for a whole country or a community, may be made with the aid of statistical data of the economic development and number of subscribers.

   One way of making such estimates is to assume that

   the relative increment in demand is proportional to the relative increment in economic activity.

   This assumption leads to the following relation:

$$\log Q = C_0 + C \cdot \log Y \qquad (1)$$

   where

   Q = the demand at a certain point of time (number of subscribers or traffic)

   Y = a measure of economic activity (gross national product, income, electricity consumption . . .)

   C_0, C = constants to be determined by regression on historical data.

   The economic activity, Y, at a future point of time is estimated by extrapolation of historical data. The demand, Q, at this point of time is thereafter calculated by means of equation (1).

b) Estimate of the topographical distribution of subscribers. For a local network this estimate is based on a detailed field study (cf. fig. 8).

c) Reconciliation of the results obtained under a) and b).

In the same way the estimated inter-exchange traffic is reconciled with the aid of estimates of the total initiated (= received) traffic for the area considered and the initiated and received traffic for each exchange.

The estimation of the traffic between the exchanges may be done in different ways, of which three are described in the sequel.

One way is to assume that

the sum of the traffic from one subscriber in an exchange area, k, to all subscribers in an area, l, (in the direction k to l) and the traffic from all subscribers in area k to one subscriber in area l is constant.

This assumption leads to the following expression for the traffic, A_{kl}, at a future point of time:

$$A_k = A_{kl}^0 \cdot \frac{N_k \cdot \dfrac{N_l}{N_l^0} + N_l \cdot \dfrac{N_k}{N_k^0}}{N_k + N_l} \tag{2}$$

where

A_{kl}^0 = present traffic between exchanges k and l

N_k^0, N_l^0 = present number of subscribers in areas k and l

N_k, N_l = future number of subscribers in areas k and l.

Another assumption, viz.

the sum of the squares of the change of initiated and received traffic per subscriber shall be as small as possible

gives a similar result, viz.

$$A_{kl} = A_{kl}' \cdot \frac{N_k^2 \cdot \dfrac{N_l}{N_l^0} + N_l^2 \cdot \dfrac{N_k}{N_k^0}}{N_k^2 + N_l^2} \tag{3}$$

A third assumption is that the community of interest factor (= the traffic frome *one* subscriber in area k to *one* subscriber in area l) is reduced in proportion to the increase in the total number of subscribers. The future traffic between the exchanges is then obtained from the expression

$$A_{kl} = \frac{A_{kl}}{N_k^0 \cdot N_l^0} \cdot N_k \cdot N_l \cdot \frac{M^0}{M} \tag{4}$$

where M^0 and M are the present and future total number of subscribers within the area respectively.

A consequence of eqs. (2) and (3) is that the initiated (= received) traffic per subscriber *within* an exchange area is constant and independent of the subscriber growth.

According to eq. 4, however, the initiated traffic per subscriber increases within an area in which the relative subscriber growth is higher than the relative total subscriber growth. In the opposite case, i.e. when the subscriber growth within an area is less than the total growth, the initiated traffic per subscriber decreases.

Of the alternatives for estimating the future traffic. (eqs 2, 3, 4), eqs. 2 and 3 seem most attractive. They have at least the advantage of being based on clearly defined assumptions regarding the behaviour of the subscribers.

The above-mentioned calculations should, if possible, be carried out for each particular category of subscribers (business, residential, official . . .) separately. As already mentioned, the calculation of the inter-exchange traffic has to be reconciled with the estimates of the total initiated (= received) traffic for the whole area and with the initiated and received traffic for each exchange.

Corrections must also be made with regard to the development of an area, for instance the character of new buildings, rebuilding, and residential areas expected to develop into industrial areas.

Provision Costs

The planning of local exchange areas and of junction and trunk networks necessitates a knowledge of the following classes of provision costs:

- sites and buildings
- switching equipment
- circuits of different kinds, physical and carrier.

Cost calculations and selection studies of different possibilities to cater for the demand are greatly facilitated by dividing the plant into units called plant units. For example, a typical plant unit would be 1 km of 100-pair buried cable containing, besides the cable itself, other materials such as protective tiles, splicing materials etc. Examples of other plant units are conduits including manholes per km, pole lines per km, terminals and telephone instruments.

The costs of plant units may include the cost of materials, freight, storage, installation, overheads, general expenses etc. With the help of these costs for plant units the cost of different kinds of installations may be divided into certain *elementary costs*, which is of importance for a great many calculations, for instance for determining the applications for different kinds of circuits, such as physical and carrier circuits.

Thus the cost for a cable route may be written

$$C = al + (bl + c) \cdot n \tag{5}$$

where

l = length of the cable

n = number of circuits in the cable

a = cost per unit of length (basic cost for cables)

b = cost per unit of length and circuit

c = cost per terminal (main distribution frame, cross-connection points, amplifiers, switching equipment).

Correspondingly the cost for a conduit route with n ducts is

$$C = (a + bn) \cdot l \qquad (5\text{ a})$$

where

a = cost per unit of length (basic cost per conduit, excavation)

b = cost per unit of length and duct

The cost for a whole cable (or conduit) network excluding terminals is consequently

$$C = a \sum l + b \sum nl \qquad (5\text{ b})$$

where

$\sum l$ = sum of the cable lengths

$\sum nl$ = sum of the numbers of circuits × length

The cost for a cable run equipped with a carrier system of a specific type may be written

$$C = C_0 + al + cn \qquad (6)$$

where

C_0 = cost of system terminals

a = cost of coaxial tubes and amplifiers per unit of length

c = cost per carrier terminal and switch.

Fig. 4 shows as an example a comparison between the costs for a 300-channel system equipped with 150 and 300 terminals and physical circuits dimensioned for a total attenuation of 2 and 4 dB as a function of the length of the route. When making such comparisons it is important to take account of the estimated future increase of demand. This is because the economic provision period for a cable (especially a buried cable) is long in comparison with the provision period for carrier terminals, resulting in a reduced present value for the cost of a carrier system. For the same reason the extensions of a carrier system may be more smoothly adjusted to an uncertain growth in demand.

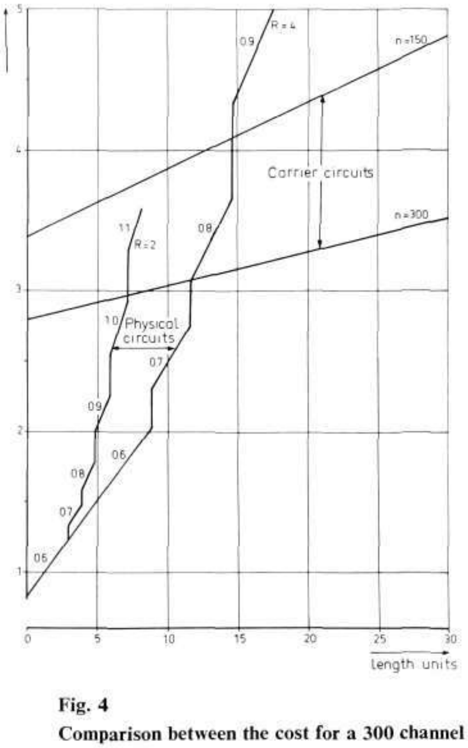


Fig. 4

Comparison between the cost for a 300 channel system equipped with 150 and 300-terminals and physical circuits (loaded) dimensioned for R = 2 and R = 4 dB permissible attenuation

For the determination of the number of circuits on high-usage routes *the incremental cost* is of importance.

For physical circuits the incremental cost is

$$B = bl + c \qquad (7)$$

i.e. the cost per circuit and the cost per terminal.

For a carrier system of specific capacity the incremental cost is c, i.e. only the cost per terminal.

For the determination of the number of exchanges the basic cost of the switching equipment (= cost independent of the number of lines) is of importance.

The cost of the switching equipment may be written

$$C = a + bn \tag{8}$$

where

a = basic cost of switching equipment

b = incremental cost for switching equipment.

The magnitude of the constants a and b depends on the system used and on the initiated traffic per subscriber in the exchange area. When making cost comparisons the cost of the site and building is added to the basic cost a in eq. 8.

The incremental cost/pair-km for the primary network is approximately

$$b_m = b_p + \frac{a_p + b_d}{P_m} \tag{9}$$

where

a_p = basic cost of primary cables

b_p = incremental cost for primary cables

b_d = incremental cost for conduits (cost/duct)

P_m = a mean value for the size of cables in the network.

Eq. 9 may be used for estimating the cost of the primary network under different assumptions regarding the number of exchanges. We note that the basic cost of conduits (see eq. 5a) is not included in this formula as this cost is fairly independent of the number of exchanges, at least when the size of the exchange is not too small. For small exchanges the basic cost of conduits (or burying of cable) is rather high in comparison with the cost of cables, and it may be necessary to sketch the cable runs and calculate the cost for each particular assumption regarding the number of exchanges. Finally, for very small exchanges aerial cable may be used to a large extent.

Expected Service Life, Maintenance and Operating Costs. Rate of Interest

The components of operating and maintenance costs are

- labour and related overheads
- material and repair parts
- cost of tools, vehicle operation, supervision and general administrative expenses.

The operating and maintenance costs and the expected service life depend to a large extent on the exchange and network system as well as on local conditions and should be estimated for each special case. The following data may serve as an example and for general guidance.

Plant unit	*Service life in years (about)*	*Maintenance plus operating costs as a percentage of the provision cost (about)*
Conduits	40	0.7
Conduit cable	25	1.0
Buried cable	25	1.2
Exchange equipment	30	1.0
Carrier system	25	1.0

When making cost calculations it is convenient to include the costs of replacements, maintenance and operation in the provision cost. This is done by multiplying the provision cost by the following present value factor (μ):

$$\mu = 1 + \frac{1 - s}{(1 + r)^T - 1} + \frac{u}{r} \qquad (10)$$

where

T = service life of the plant

s = scrap value of retired plant (reduced by the dismantling cost) in relation to provision cost

u = annual operating plus maintenance costs in relation to provision cost

r = interest factor

In this expression the first term is proportional to the provision cost, the second to the present value of net replacement costs and the third to the maintenance plus operating costs.

The *rate of interest* to be used in the economic selection studies cannot be established once and for all—the circumstances must be considered in each particular case.

If the investments are financed out of loans, the interest should be at least equal to the interest on currently loaned capital.

When the corporation's own capital is used, the interest should be at least equal to the normal yield on telephone operation.

The amount by which the interest should be further increased depends partly on the risk that is subjectively ascribed to the investment and partly on the supply of capital.

With limited supply of capital the point of time for extensions may be deferred with regard to optimum use of capital.

To ensure an optimum use of capital the equipment should theoretically be installed at a point of time when the yearly cost for the invested capital is equal to the yearly revenue for the number of waiting subscribers.

To illustrate, suppose that the installation cost is 500,000 monetary units, the number of subscribers on the waiting list at $t = 0$ is 50, the increase in the number of subscribers 100 per year and the rate of interest 10 %. In this case the installation could be deferred without financial losses for a time t obtained from the equation

$$500{,}000 \cdot 0.1 = (50 + 100\,t)\,200$$

$$\text{i.e } t = 2 \text{ years}$$

at which time 250 subscribers would be on the waiting list.

Under unfavourable conditions of capital availability the rate of interest may be high, 15–20 %.

Finally the costs should be calculated with regard to the fact that it is economical to extend a plant in stages determined by the increase in the need and that therefore an installed unit can generally not be fully utilized immediately. Thus, if the provision cost for a main cable is 100 monetary units, the present value factor $\mu = 1.5$ and the mean utilization 75 %, the cost to be used in the calculation is

$$\frac{100 \cdot 1.5}{0.75} = 200 \text{ monetary units}$$

The Transmission Plan

An adequate transmission level entails requirements in respect of the types of circuits to be used in subscribers' and junction networks.

Therefore the plan must also embrace the determination of the most economical types of circuits for all kind of connections.

According to CCITT recommendation *P 11* the maximum nominal reference equivalents for the sending and the receiving system of a country are:

- for sending, SRE = 20.8 dB (24 dN)
- for receiving, RRE = 12.2 dB (14 dN)

The allowed part of the transmission equivalents allocated to the two-wire multi-exchange network is illustrated by the following example, fig. 5, taken from the Red Book, Vol. V bis, rec. *P 11*.

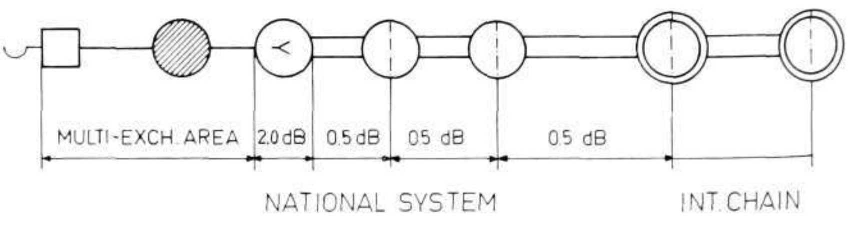


Fig. 5
The allowed part of transmission equivalents allocated to the two wire multi-exchange area
SRE = 20.8 − 3.5 = 17.3 dB (20.0 dN)
RRE = 12.2 − 3.5 = 8.7 dB (10.0 dN)

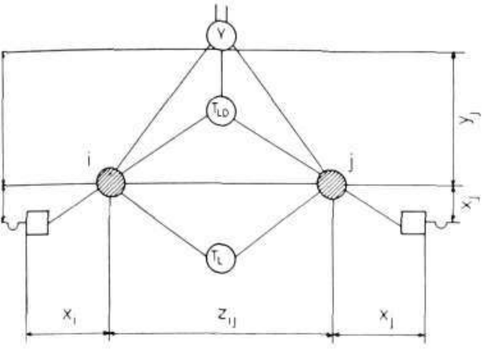


Fig. 6
Tandem switching with separate tandem stages for local and long distance traffic

T_L = tandem stage for local traffic

T_{LD} = tandem stage for long distance

SRE+RRE = $X_i+Z_{ij}+X_j \leq$ 33.0 dB (local traffic)

SRE = X_i+Y_i $\leq$ 17.3 dB (long distance traffic)

RRE = Y_j+X_j $\leq$ 8.7 dB (long distance traffic)

The distribution of the reference equivalents in a multi-exchange area with separate tandem stages for local and long distance traffic is shown in fig. 6.

When the local traffic between the exchanges is small, it may be economically justified to use one (or several) tandem stages for switching local traffic as well as long-distance traffic. This routing diagram is shown in fig. 7.

The equations are the same as for routing with separate tandem stages for local and long distance traffic (cf. fig. 6).

According to the CCITT recommendation the maximum nominal reference equivalents for the sending and receiving systems for a multi-exchange area are fixed, but the division of these equivalents between subscribers' network and junction circuits is left to the discretion of the administrations.

From the point of view of economic theory the permissible reference equivalent should be divided between the subscribers' network and junction circuits in such a way that the total costs are as small as possible.

In order to establish a transmission plan with this aim the following information is required:

- pair-km distribution in the subscribers' network for all exchanges
- distance between exchanges and number of junction circuits
- costs per pair-km for cables of different conductor diameter and loading, voice frequency repeaters and carrier systems.

The result of such a study, however, must be used with discretion and the theoretical transmission plan can only serve as a guide for the administration's decision on the definite plan. The endeavour to reduce the immediate installation costs must not be carried too far. Future development can never be predicted with great accuracy. Therefore, in order to avoid difficulties and unnecessary expense in connection with future installations of new and longer circuits, the loss between any two exchanges should not exceed a predetermined value, say 12–15 dB, and unloaded junction cables should be used with discretion. For the same reason the transmission losses between the tandem exchanges should not be too high, say 2–4 dB.

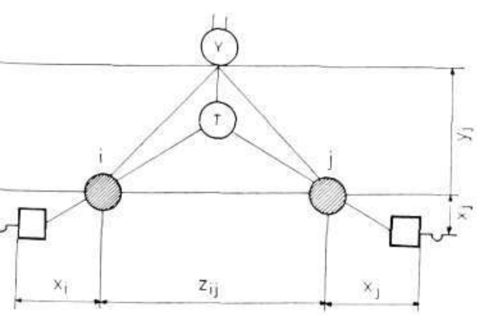


Fig. 7
Tandem switching with a tandem stage for combined local and long distance traffic

Another important question in connection with the transmission plan is to decide whether the local and trunk traffic from a local exchange to its primary centre shall be carried over the same or separate junctions of different conductor diameters and loading.

If the local traffic between these two exchanges is large, considerable savings may be made by using separate junctions. If, on the contrary, the local traffic is small, no savings are made and local and trunk traffic can be advantageously carried over the same junctions. In the latter case the junctions must be planned to conform with trunk circuit standards.

The Telephone System of the Finnish State Railways

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UDC 654.254.1(480)
LME 837 823

The Finnish State Railways use in their telephone network material and equipment supplied to a large extent by Telefonaktiebolaget L M Ericsson. The various units of the telephone system interwork through L M Ericsson's compelled sequence MFC signalling system which was introduced in August 1965. In 1967 a contract was signed with L M Ericsson for the supply of an additional 24 exchanges. This article presents a survey of the railway telephone network and of the mode of operation of the signalling system.

The total length of the Finnish railway lines is around 5800 km (Fig. 1). The Railway Board is situated in Helsinki, far from the geographical centre of the country. The longest distance from Helsinki to the northernmost part of the network is over 1000 km.

The railway telephone network is usually not combined with the national public telephone system; sometimes, however, pole lines and cables are used jointly by the two administrations (the Railways and the PTT). Roughly 700 km of the lines run in cables, but the bulk of the network, more than 5000 km, is still, and will be based on bare wire lines.

Automatization of the railway telephone network was planned by a committee consisting of experts from the Railways, the PTT and the Helsinki Telephone Association. Special attention was devoted to the troublesome form of the network (tied to the railway lines) and to strict requirements of reliability.

This article describes the telephone system in broad outline. It is hoped that the account may be of use to those who are planning telecommunication systems for railways or to other organizations requiring a separate telephone network.

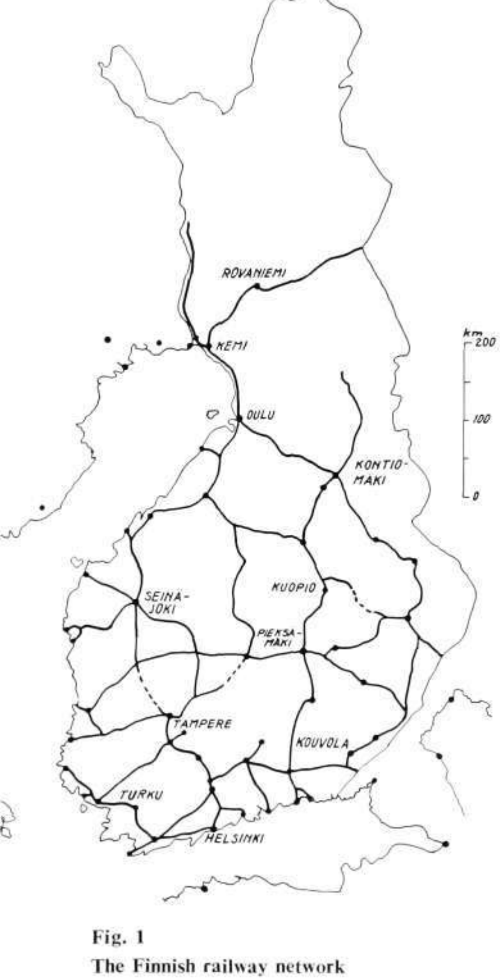


Fig. 1
The Finnish railway network

Layout of the Network

According to the present plans there will be altogether eight transit or zone centres which use four-wire through-connection for the long distance or junction traffic. The junction lines and the zone centres form a lattice-shaped network, which may be recommended from the reliability aspect.

Around each zone centre there is a number of group centres and terminal exchanges, both working on the two-wire principle. In special cases a satellite exchange may be connected.

To limit the line costs, the telephone sets at the smaller intermediate stations are connected to selective calling systems which are connected to telephone exchanges at the main railway stations.

At all exchanges there are in principle four categories of lines: direct junction lines between exchanges, selective calling lines, local extensions, and lines to the local public exchange.

As regards the latter category the railway exchanges operate as *PABX*.

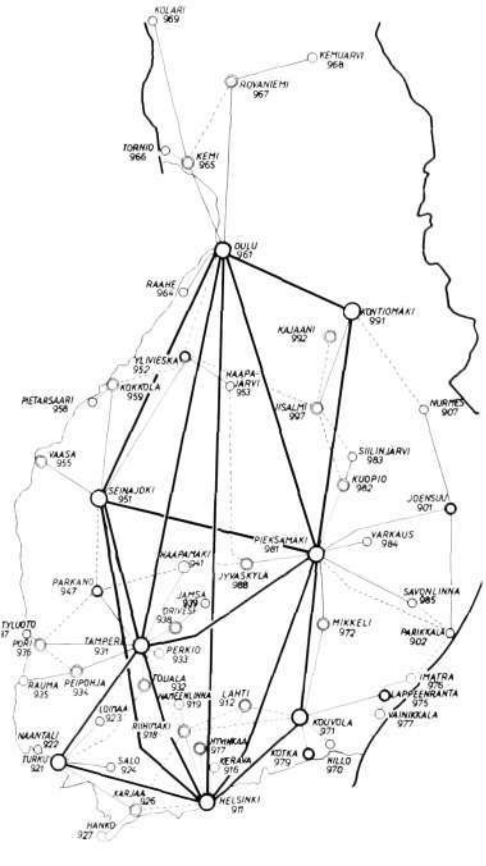


Fig. 2
Plan for automatization of the railway telephone network

- Transit centre
- Group centre
- Terminal exchange
- Junction circuits

Numbering

For the long distance traffic a self-contained numbering system is used without intermediate tone. Each exchange has a three-digit area code starting with digit 9. The local number consists of two, three or four digits. A call to a telephone connected to the local exchange is made by dialling the local number. If the call is for another exchange, the area code is dialled, immediately followed by the local number without interruption. To make a call, for example, from Turku (921) to the station inspector at Kuopio (982), 982201 is dialled. The same number is dialled if a call comes from Pieksämäki (981), but in Kuopio itself only the local number 201 is used.

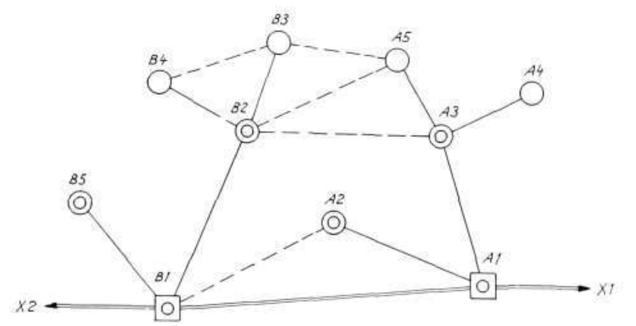
As assistance to the memory officials of equivalent grade are given the same number in all exchanges, e.g. 201 station inspector, 212 yard master, 335 engine-shed. Helsinki, however, has the digit 3 preceding the local number as the exchange has more than 1000 outlets.

Alternative Routing

The zone centres are equipped with registers and markers for setting up of connections, which is done on the alternative routing principle when the direct route is engaged or out of operation. If route 911–961 in fig. 2 is engaged, the next route to be tested will be 911–981–961. If this route as well is inaccessible (it may be engaged between 981 and 961, to which 911 does not have access until 981 has been tested), a third test is made via 911–931–951–961. As a rule there are at least two routes between each two zone centres.

The group centres and terminal exchanges can also have direct lines to more than one zone or group centre. For a call from 982 to 997 the direct circuit is first tested, and secondarily the ordinary route 982–981–991–997.

Fig. 3 shows the general alternative routing facilities for group centres and terminal exchanges.



From	To	Route 1	Route 2	Route 3
A1	B1	A1—B1		
A1	A2	A1—A2		
A1	A3	A1—A3		
A1	A4, (5)	A1—A3—A4, (5)		
A1	B2, (3)	A1—B1—B2, (3)		
A2	A1	A2—A1	A2—B1—A1	
A2	A3, (4)	A2—A1—A3, (4)	A2—B1—A3, (4)	
A2	B2, (3)	A2—B1—B2, (3)	A2—A1—B1—B2, (3)	
A3	B2, (3)	A3—B2, (3)	A3—A1—B1—B2, (3)	
A5	B4	A5—B2—B4	A5—A3—B2—B4	A5—A3—A1—B1—B2—B4
B3	A5	B3—A5	B3—B2—A5	B3—B2—B1—A1—A3—A5
A2	X1	A2—A1—X1	A2—B1—A1—X1	
A2	X2	A2—B1—X2	A2—A1—B1—X2	
B2	A2	B2—B1—A2	B2—B1—A1—A2	

Fig. 3
Alternative routing facilities for group centres and terminal exchanges

Transmission System

All junctions between zones, and some of the direct lines, consist of 3 or 12 channel carrier circuits. These are of different types, some based on electron tubes, others transistorized. No problems have arisen as a result of differences of equipment, but some important points in the transmission techniques should be mentioned.

- The bare wire lines should be carefully built with regular pole spacing and suitable transposition, especially when several 12-channel systems are installed on the same pole line.

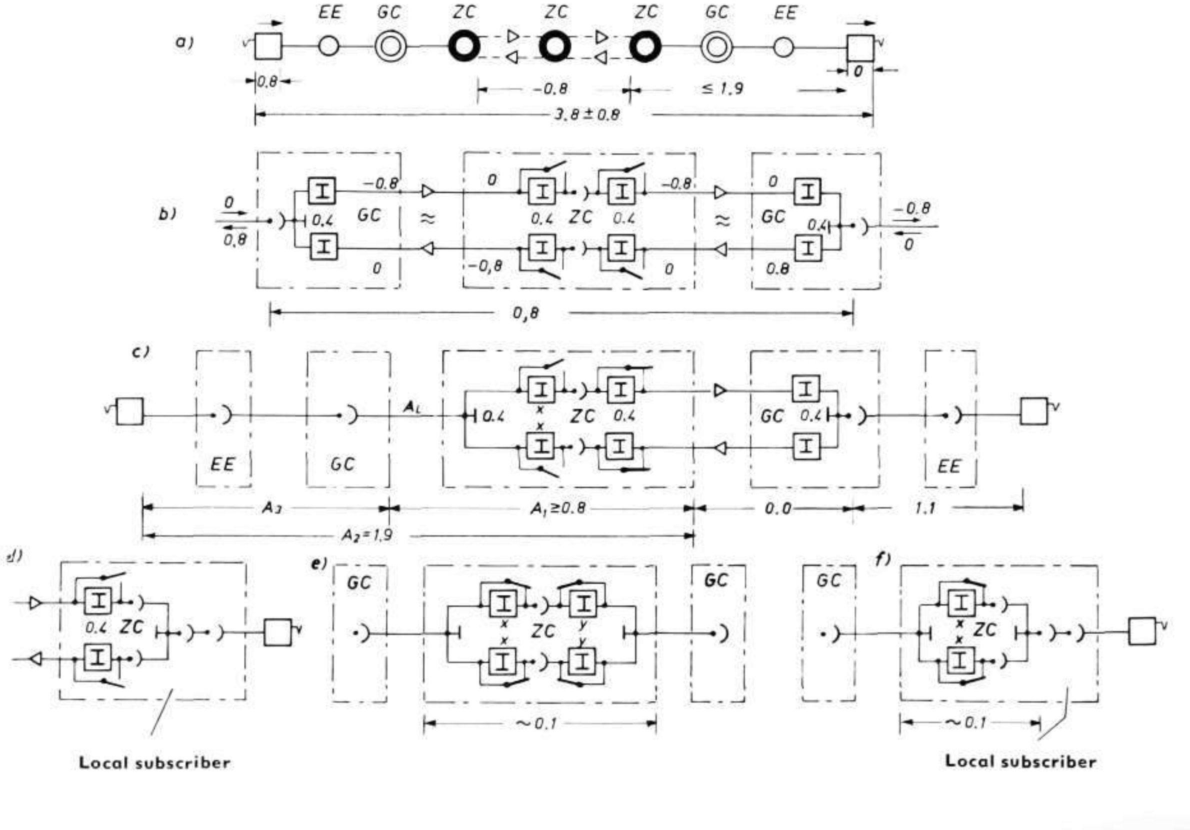
- In Finland the variation of attenuation is very great as the lines are exposed to varying weather conditions—from dry weather to heavy ice and frost. For automatic compensation of the variation of attenuation there are two pilot channels in both directions when 12-channel systems are run on overhead lines, while the 3-channel systems work satisfactorily with one pilot channel.

- Physical circuits are used for the junction lines to group centres and terminal exchanges. To preclude the necessity of voice frequency amplifiers on the physical circuits, the carrier circuits are normally adjusted so that the input level is − 0.8 Npm0 and the output level 0 Npm0 (with four-wire connection). Thus a gain of 0.8 Np is obtained without cost when a physical circuit is connected to a carrier circuit in a zone or group centre. A minor difference of level had been planned from the outset, but in practice no problems have arisen although this large difference of level is used to attain better gain.

Fig. 4 shows the entire attenuation scheme. The total loss is normally 3.8 Np. At times there are variations of ± 0.8 Np. Thus the maximum loss which may arise between the microphone of the telephone set and the receiver of another is 4.6 Np.

Fig. 4

a) General attenuation scheme in Np and Npm0 units
b) Zone centre with two four-wire circuits
c) Zone centre with one two-wire and one four-wire circuit
d) Termination of a four-wire circuit in the local network
e) Zone centre with two-wire circuits
f) Termination of a two-wire circuit in the local network



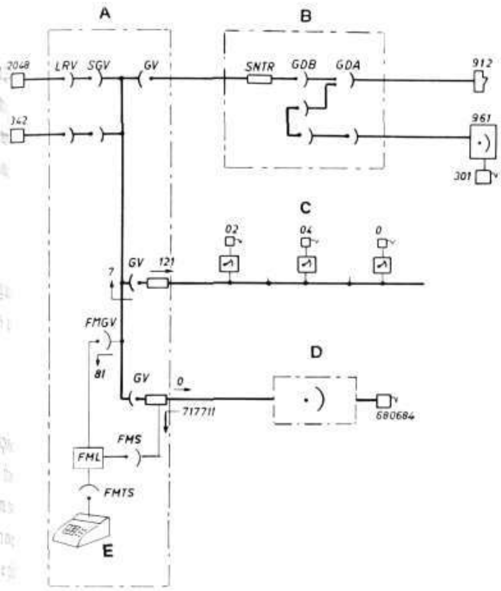


Fig. 5
Trunking scheme for Helsinki zone centre
A Local equipment
B Transit exchange
C Selective calling line
D Public exchange
E Operator

In the middle of fig. 4 b there is a zone centre which interconnects two four-wire circuits, in this case two group centres. If the junction circuits between different zones are to be through-connected, the circuit diagram for the zone centre will be the same.

Two-wire circuits from group centres have four-wire terminations at the zone centre (fig. 4 c). The pad x is so adjusted that attenuation between the group and zone centres is roughly 0.8 Np. If the line to the group exchange is too long, an amplifier is used instead of a pad.

A four-wire junction circuit terminates on the local equipment of a zone centre as in fig. 4 d. The hybrid and the 0.4 Np pad together provide the 0.8 Np attenuation necessary for stability.

If two-wire circuits from a group centre are interconnected in a zone centre (fig. 4 e), the individual pads x and y are bypassed and the total loss caused by two hybrids is then about 0.1 Np.

To a large extent the same loss is obtained when a two-wire junction circuit is connected to the local network as shown in fig. 4 f.

Types of Exchange

There are today six zone centres, two group centres and a terminal exchange in operation. The zone centres consist of two parts (fig. 5): the local *PABX* equipment and the transit exchange. All transit exchanges are of L M Ericsson crossbar type *ARM 301*, while there are three types of local *PABX* equipment, one the more than 15-year-old L M Ericsson type *AGD* with motor-driven 500-line selectors, a modern L M Ericsson crossbar type *ARD 321* for small exchanges, and LM Ericsson's type *ARD 321* for Helsinki, with at present 1200 extension lines connected. The group centres and terminal exchanges are of type *ARD 321*.

The special advantages of modern *PABX* are drawn upon to a large extent. Automatic enquiry and transfer from one extension to another are possible not only on calls via the public network but also on long distance calls on the railway telephone system. In Helsinki and at some other exchanges automatic call-back facilities are provided. If the called party is engaged, the number can be stored in a register and when the line becomes free the call is set up automatically. In the meantime the caller's telephone is free for other calls. A radio paging system is also connected to some of the exchanges.

Fig. 6
General view of the Helsinki exchange. The room is built underground, of prefabricated concrete elements; note the particular form of the ceiling. Automatic traffic metering equipment and a multirecorder are placed on the table. The carrier equipments and the teleprinter station are situated at the other end of the room. In the centre, therefore, there is adequate space for future expansion.

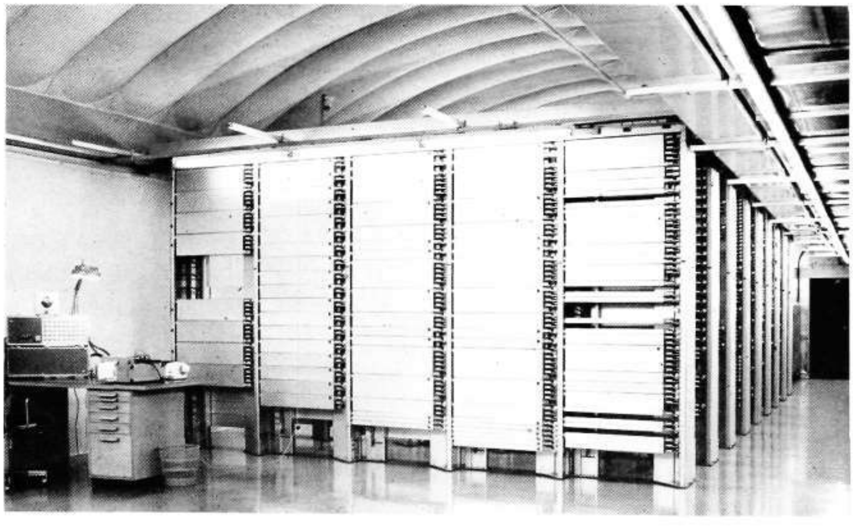


Fig. 7
Operators' room. Each operator has her own cordless console. To permit the operators to give quick information, there are revolving card indexes.

The local extensions are divided into the following categories:

Group a) is entitled to all kinds of external traffic, including long distance calls on the public network.

Group b) is entitled to all railway calls and local public calls; but when digits 09 to the public junction circuits are dialled, busy tone is returned. Operator assistance can be obtained, however, for putting through calls on public junction circuits.

Group c): Busy tone is returned on dialling of 0, but the operator can extend calls to and from the public network.

Group d) has no connection with the public network.

Group e) is debarred from all external traffic except on selective calling lines. All exchanges are fed with 24 V. The same power source is used also for transistorized carrier and radio link systems.

Signalling

All local circuits, selective calling circuits and also long distance circuits outside the interzone network operate with 10 pulses/sec signalling. The zone centres, however, are equipped with registers which can convert the pulses to voice frequency code and vice versa. The code consists of two-out-of-six frequencies in the outgoing direction and two-out-of-three frequencies in the incoming direction. Altogether, therefore, 9 frequencies are used.

Fig. 8 shows an example of a call passing through three zone centres. The first zone centre controls the entire connection up to the last zone centre. All code combinations are transmitted until an answering code is received as an acknowledgement or "proceed-to-send" signal. This results in compelled sequence signalling. The next digit cannot be sent unless both frequencies for the earlier digit have been received. If the attenuation is sometimes exceptionally high or if any disturbance occurs, the transmission time for a digit is automatically prolonged. Normally the transmission time is roughly three digits per second.

The two-out-of-six code provides 15 combinations, i.e. five more than are needed for the digits. The redudancy is reserved for certain special purposes.

With few exceptions outband signalling is used on the carrier circuits: for seizure and answering signals, clearing within the interzone network, and for pulsing in group centres and terminal exchanges.

On physical circuits A.C. pulsing is used, with roughly 70 Hz. The alternating current is obtained from relay converters for each individual line and the converter is started and stopped between each two pulses in order to obtain pulses of equal length.

To ensure the possibility of making an emergency call under any conditions, two indications of origin are used, a pulse if the call comes from an ordinary extension, and two or three pulses if it derives from an operator's equipment. In the latter case the operator, even if the remote section of the circuit is engaged, can send a special signal to the conversing parties and request them to replace their handsets so that the emergency call can be put through.

Selective Calling

There are many different forms of selective calling system in the world. Some of them work with a low pulse speed of 4–6 pulses per second and are mainly designed for train dispatching. These systems are not suited for connection to automatic exchanges.

All modern selective calling systems work with 10 pulses per second or with voice frequency code. All of them can generally be connected to automatic exchanges without great difficulty, but a special relay set is required between the selective calling circuits and the exchange. The relay set varies depending on the type of selective calling circuit and exchange.

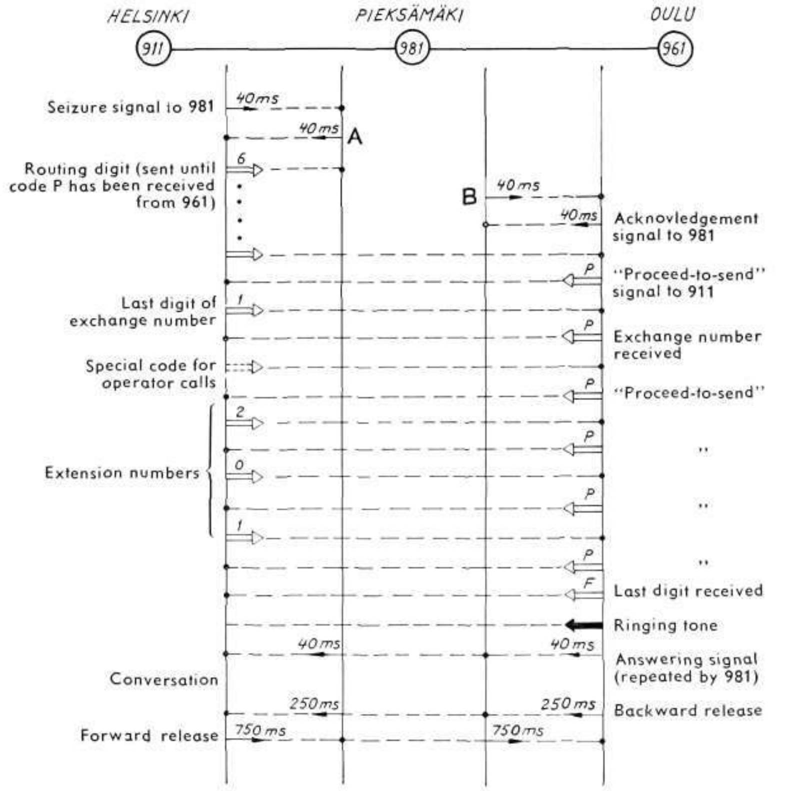


Fig. 8
Example of compelled sequence multifrequency code signalling

- A Acknowledgement signal to 911
- B Seizure signal to 961
- → Line signal from terminal equipment
- ⇒ Multifrequency code signal from register (two simultaneous frequencies)
- • Receiving point for a signal
- ← Audible tone

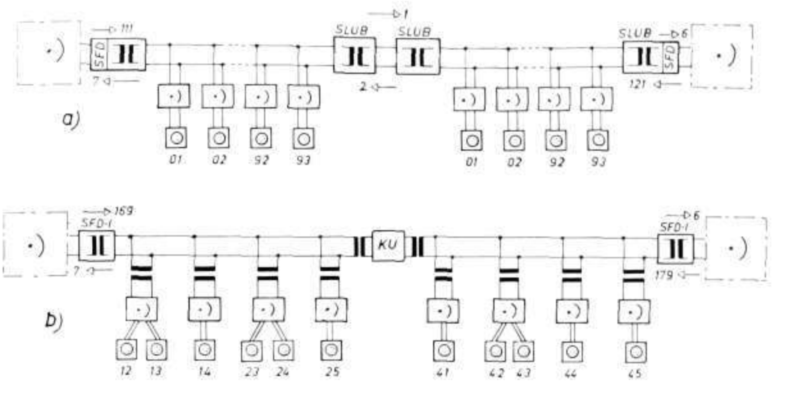


Fig. 9

Automatic selective calling circuits connected to the exchanges

a) L M Ericsson's ATA system with self-contained numbering scheme for area codes (routing digits) and D.C. pulsing

b) Finnish selective calling system with inductive pulsing and linked numbering scheme

The Finnish Railways employ two kinds of automatic selective calling system. In southern Finland LM Ericsson's D.C. system *ATA* is used at the stations (fig. 9 a). The line is divided into sections, each of which has an active line equipment *SLUA* and usually also a passive equipment *SLUB* (nowadays the same line equipment *SLUAB* can be connected to both terminal points). Within each section the telephones have individual numbers, but between the sections a routing digit must be dialled before the number. Pulsing from the telephones is done on a 24 V D.C. loop fed by *SLUA* equipments. These dial pulses are repeated by the line equipment and transmitted on the line at 200 V D.C. and with reversed polarity. These high voltage D.C. pulses step the selectors along the line.

Another system is in general use in northern Finland and also in southern Finland for the Permanent Way Department (fig. 9 b). The system has no terminal equipments for pulsing, but each telephone set can send and receive high voltage pulses. These are generated by 6 V or 34 V lead cell batteries by connecting a current on and off the primary winding of a transformer, whereupon the secondary winding delivers inductive pulses of 130–150 V. In each telephone set there is a telegraph relay which supervises the function of a relay chain in accordance with the inductive pulses received. In this system as well the lines are divided into sections, but a linked numbering scheme is used for the entire line. The first digit determines the section desired.

This was originally a German system, but the Finnish Railways have entirely redesigned it and excluded all rotary selectors. This equipment is now delivered by the Finnish telecommunications industry.

Both selective calling systems are connected to the L M Ericsson exchanges. The special relay set for the inductive system was designed in cooperation between the Railways and L M Ericsson. The limit between the exchange and the inductive system runs in front of the pulse transformer, and therefore the exchange side of the relay set works with direct current.

Fig. 10 shows an example of the numbering around Oulu. South of Oulu there are two selective calling lines, one for stations only, and the other both for stations and permanent way personnel. If a call is addressed to a station, the correct route selection number is 111, after which the station number is immediately dialled. Through the dialling of 111 the exchange seizes the station circuit, if free; if it is engaged, the call goes to the other line. The station numbers are the same on both lines. If a call is to a lineman, route number 111 alone is used, and in this case the exchange does not switch the call to the station circuit if the desired line is engaged.

In the opposite direction the circuit is connected to the exchange by dialling routing digit 7. Answering tone must then be awaited before other digits can be dialled.

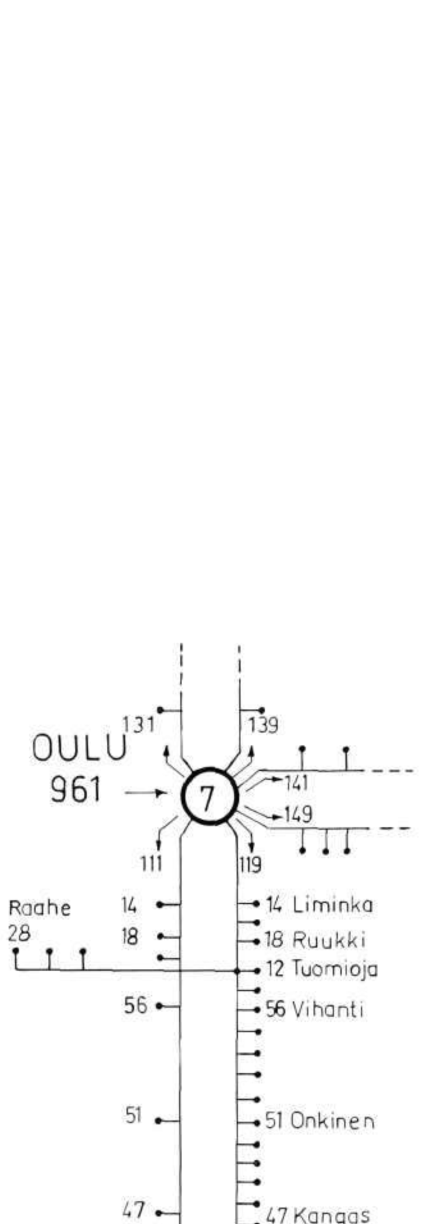


Fig. 10

Numbering scheme for selective calling circuits at Oulu

Table 1. Traffic measurement on Tampere lines 1—6 during the period May 21—26, 1965.
Route: Tampere—Seinäjoki (all digits fictitious)

Day	Number of engaged lines observed every fifth minute			Total occupations in busy hour	Observer
	9.00—10.00	10.00—11.00	11.00—12.00		
Monday	3 3 - - 3 2 3 1 2 3 3 3	3 2 - 1 3 2 3 2 2 3 1 3	3 2 2 - 1 - 2 1 1 1 1 1	(27)	PL
Tuesday	5 2 3 2 2 5 2 1 - 2 1 1	1 3 3 3 2 2 5 1 1 2 2 2	3 1 2 2 - 1 - 1 2 3 1 2	29	PL
Wednesday	2 5 5 2 3 3 4 1 1 4 2 2	3 1 1 1 4 4 2 2 4 3 2 4	4 3 3 4 3 3 3 2 1 3 3 2	39	PL
Thursday	1 2 4 5 4 3 - 2 3 2 1 3	4 2 2 2 4 5 3 3 3 4 5 3	3 2 2 2 2 - - 2 3 - - 1	40	PL
Friday	4 3 4 6 3 5 3 3 4 2 2 3	2 3 4 4 1 4 3 2 1 2 3 4	2 3 - 1 1 2 4 1 2 2 3 2	42	PL
Saturday	1 4 3 3 2 4 2 3 2 2 - 1	- 1 2 2 1 3 1 2 2 2 5 5	- 3 3 3 3 3 3 1 3 4 4 1	37	PL
			Total	187	
			Mean traffic intensity in erlangs	3.11	

Traffic Calculations

The railway telephone traffic differs in character from ordinary *PABX* traffic. A large part of the calls are destined outside the local area. It may also be difficult to present formulae for railways in general, since the administrative scheme and the use of the telephone may vary much from railway to railway. To arrive at a suitable level of equipment provision for the exchanges, and especially for the traffic routes (number of circuits per route), the Finnish Railways have made systematic measurements of the telephone traffic since 1950.

Table 1 shows a traffic metering form used for records of the traffic both through manual exchanges and through automatic exchanges in which there is no automatic metering equipment.

Every long distance route has its own form. Every fifth minute the number of engaged lines is counted and entered on the form. Every day the number of occupations during the busy hour is noted. At the end of the week the total number of busy hour occupations is counted for five successive days (from Monday to Friday or Tuesday to Saturday). The total corresponds to the number of minutes of conversation per average busy hour and, divided by sixty, this gives the traffic per busy hour in erlangs.

There is a tendency to increasing volume of traffic after changing from manual to automatic operation. It should also be noted that, if for example there are three circuits on a long distance route and the traffic measurement shows that they are engaged all day long (3 erlangs), this value cannot be used for equipment provisioning of a new system. The Finnish Railways have used estimated "traffic increase coefficients" which, on conversion from manual to automatic long distance traffic, vary from 2 to 3.5.

Table 2 shows how the traffic is analysed for equipping a group centre. The traffic increase coefficient has already been applied to these figures.

Table 2. Estimated traffic distribution at a group centre ARD 321

	▶	a) *PBX*	b) *SFD*	c) *FDR-C*	d) *FDTR*	Total of a—d	Num. of lines
Local extensions	*PBX*	10.8	0.45	2.5	5.5	19.25	240
Selective calling lines	*SFD*	0.45	0.05			0.5	11
Exchange lines	*FDR-C*	2.5				2.5	8
Junction lines	*FDTR*	5.5			2.5	8.0	20
Incoming traffic		19.25	0.5	2.5	8.0	30.25	

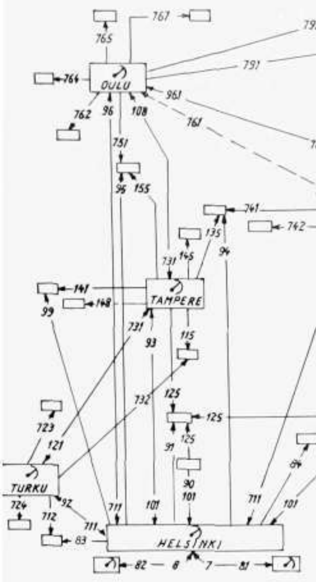


Fig. 11
Intermediate stage for subscriber-dialled long distance traffic prior to August 1965

Intermediate Stages in Conversion to Automatic Operation

Before the multifrequence code system and the four-wire exchanges had been fully developed, there were already a number of automatic local exchanges in use (see fig. 11). A self-contained numbering system was adopted and the switches were operated by means of trains of pulses. The necessary line relay sets, working with a simplified method of signalling, were developed and produced partly by the Railways and later (for exchange type *ARD 321*) by L M Ericsson.

The manual exchanges around each automatic exchange had and still have facilities for semiautomatic traffic—when the exchange number (or previously the route number in a self-containing numbering scheme) is dialled, the operator is called. The operator can then dial outgoing calls on demand. The line equipments between the automatic and manual exchanges are the same as will later be used after complete conversion to automatic operation.

When the new system with six zone centres had been installed, the entire network was altered within a few hours from the structure shown in fig. 11 to its present form (fig. 12). At the same time three old local exchanges in Helsinki were replaced by the present large exchange, all jumpering in the local network was performed, and alterations of the signalling precedure were made in 38 towns and stations throughout the country. In this way a lenghty and complicated makeshift arrangement, which might have been necessary if the new zone centres had been commissioned one by one, was avoided. Preparations for the change-over took several months and no interruptions of service were allowed.

Experience and Future Plans

During the first year certain interruptions of service have occurred principally at the large local exchange in Helsinki, as it was the first equipment delivered of this kind. The difficulties have now been entirely cleared up, and is should be mentioned that not a single fault has occured in the multifrequency code equipment throughout this period (nearly two and a half years). The long distance signalling appears, generally speaking, to be very reliable and the audibility is satisfactory throughout the network, irrespective of the number of zone centres in the transmission chain.

The realization of the entire plan (fig. 2) will take several years. Towards the end of 1968 deliveries are to be made of 24 new group centres and terminal exchanges, but there will also be a need for two additional zone centres and several more group centres and terminal exchanges.

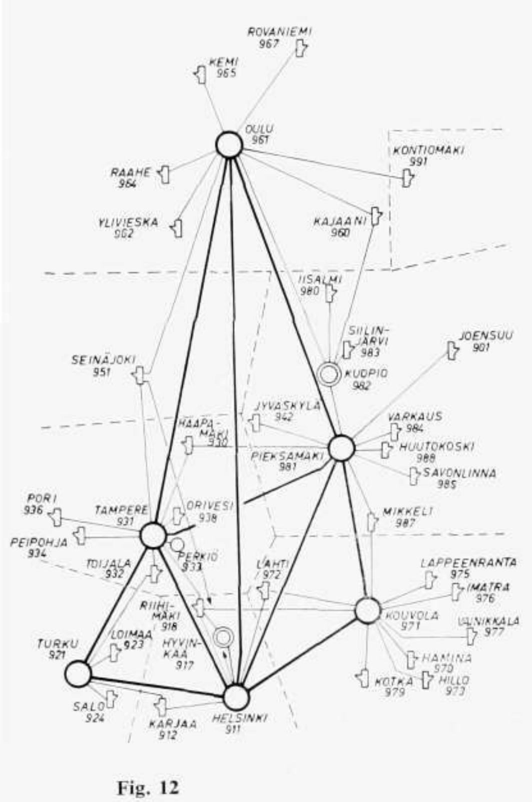


Fig. 12
Extent of automatization in 1967

ERICSSON News from All Quarters of the World

Successes for L M Ericsson throughout the World

(Top)

From the signing of the AKE contracts with Denmark. (From left) Ib Hylstrup-Larsen and Hans Laursen, both from the PTT, Johs Rosbaek, Copenhagen Telephone Company, Werner Hjort, Fyn Municipal Telephone Company, Fred Sundkvist and Malte Patricks, LME, and Lars Ch. Norrelund and Knud Riis-Petersen, both from LMD.

(Centre)

The signing of the agreements with Hungary. (From right) Mr. István Kincses, Director General and Chairman of the Board of Budavox, Mr. Dénes Sellö, Director General and Member of the Board of Budapest Telecommunications Factory, and Mr. Gyrgöy Kolozs, President of Budavox. (Standing, right) Mr. Peter Horvath, Director of Budavox.
(Left, sitting from left) President Björn Lundvall, Mr. Olof Hult (standing) Mr. Gösta Blume, all of L M Ericsson.

(Bottom)

The signing of the agreements with Russia. (From right, front row) Vice Ministers Ivan V. Klokov and Iosif S. Ravich, both of the PTT, Nikolai V. Vasiliev, President of Mashproborintorg and Messrs. Fred Sundkvist and Hans Flinck, both from LME.

DENMARK

A very valuable order for AKE 13—L M Ericsson's new stored-programme-controlled telephone system—has been received from Denmark. The order comprises two transit centres for national and international telephone traffic, one at Copenhagen with 20,000 inlets and one at Odense with 2000 inlets, to a total value of some 70 million Danish kronor. The contract was signed at the beginning of May.

The Copenhagen exchange, with its 100,000 equivalent lines, will be the largest ever delivered. AKE 13 has earlier been contracted for Rotterdam and Helsinki.

As the Danish order was acquired in competition with the world's leading suppliers, it is considered to have a great significance for the future international activities within the telephone exchange field, which is of such importance for the Ericsson Group.

HUNGARY

An agreement to a value of some 50 million kronor was signed in Budapest in January with the national Hungarian authorities, comprising

- delivery of complete telephone exchanges
- delivery of carrier system for 960 channels on small-diameter cable
- licence agreement for manufacture in Hungary of LME's crossbar system

Cont. on next page.

Cont. from page 81.

- licence agreement for manufacture in Hungary of carrier system for 300 and 960 channels.

At the same time the French Société Anonyme des Télécommunications (SAT) signed an agreement for delivery of coaxial cable and a licensing agreement for manufacture of such cable in Hungary. A part of these deliveries will come from Sieverts Kabelverk AB.

The agreement entered into force on March 9.

RUSSIA

In the middle of March an agreement for the delivery of five large automatic trunk exchanges of type ARM was signed in Moscow with the Purchasing Organization Mashpriborintorg. The exchanges are to be equipped for automatic toll-ticketing.

This order represents the first stage in a large programme of automatization of the traffic between the major Russian cities.

LME is also to train Russian personnel on the installation, testing and maintenance of the exchanges.

The deal is worth about 65 million kronor.

IRAQ

A contract has been signed with the Iraq Telephone Administration comprising delivery and installation of complete local telephone line plant in five cities, including the capital Bagdad. The order is worth about 14 million kronor.

The work is to be completed within three years and represents the first stage of a series of planned line plant projects extending throughout the whole of Iraq.

LEBANON

On May 7 a contract was signed with Lebanon for automatic telephone equipment amounting to about 10 million kronor.

The order covers extensions as well as new installations of local exchanges in a number of towns. It also includes extensions of automatic trunk exchanges.

TUNISIA

Deliveries of telephone equipment to an amount of about 13 million kronor were contracted during May with the Tunisian PTT.

The order comprises new automatic telephone exchanges as well as extensions of existing crossbar exchanges.

It also includes an exchange for fully automatic international and intercontinental telephone traffic, private automatic branch exchanges and telephone sets.

SINGAPORE

An order for equipment for the successive extension of the Singapore telephone network was received by LME in May. The order comprises primarily equipment for 50,000 telephone lines.

The agreement is to run for five years. A similar agreement was signed with Malaysia in the spring of 1967.

The contract with Iraq is signed by (from right) Abdul Majid al Jumaly, Minister of Communications of Iraq, and Mr. Lars Rönnebrink, LME. (Standing, from right) Nasrat Muddaris, Director General of the PTT, Bengt Odhner, Swedish Ambassador to Iraq, Olof Höstbeck, LME, Kamel al-Ani, Under Secretary in the Iraq Ministry of Communications, and A. H. Rizvi, LME, Bagdad.

Brazilian President Opens EDB's Enlarged Factory

The President of Brazil, Marshal Arthur da Costa e Silva, opened Ericsson do Brasil's enlarged factory at Sao José dos Campos on March 8 in the presence of a number of ministers and a large number of Brazilian notabilities and representatives of the press and TV. The parent company was represented by President Björn Lundvall and Mr. Arne Mohlin.

The addition to the factory extends the floor area to about 33,000 sq.m. The investments for this purpose run to some 40 million kronor. The factory at present employs 1100 persons, but the number is expected to approach 2000 within the next three years.

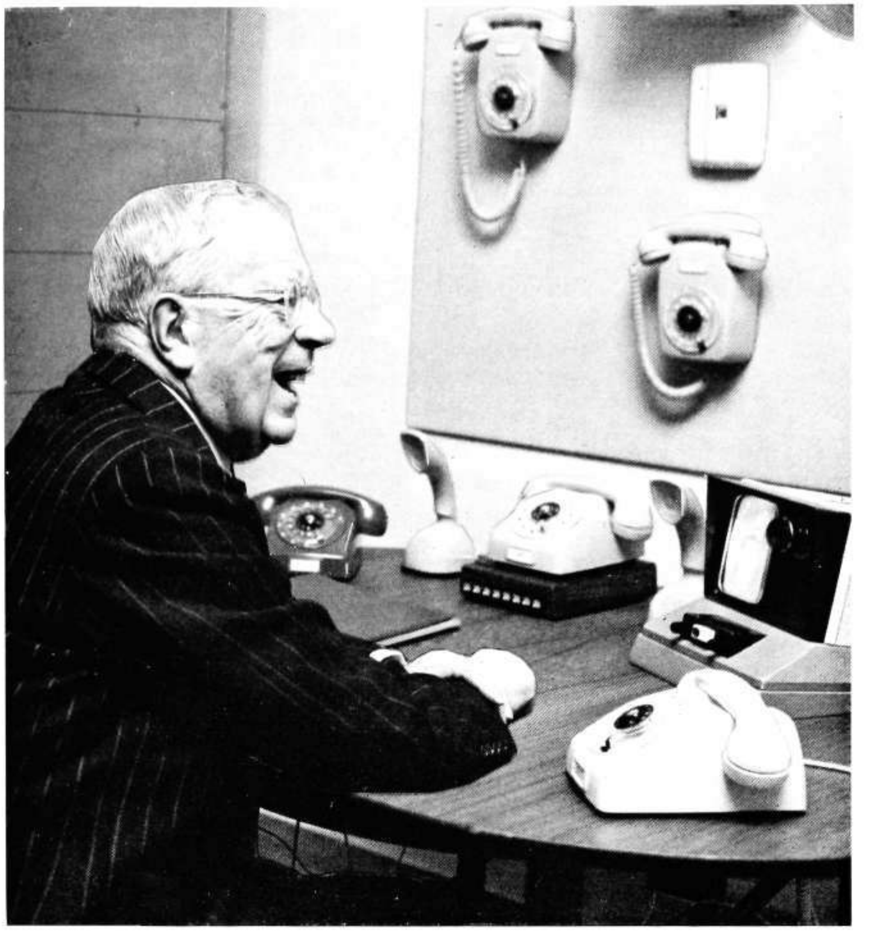
The visitors gathered at 11 a.m. and after a tour of the factory were invited to lunch. They were greeted by the Chairman of the Board of EDB, Sr. Juracy Magalhaes, and Professor Carlos Simas congratulated L M Ericsson on behalf of the Brazilian government for the fine factory and the fact that it had grown so considerably.

The Brazilian President, Marshal Arthur da Costa e Silva, speaks at the opening of Ericsson do Brasil's extended factory at Sao José dos Campos.

The President arrived immediately after lunch to preside at the official opening himself. In his speech he emphasized the great significance of telecommunications for the development of Brazil and thanked Ericsson do Brasil for its whole-hearted contributions in this field.

In conjunction with the opening ceremony the Brazilian government nominated the L M Ericsson President, Mr. Björn Lundvall, commander of the Ordem de Rio Branco.

King Gustav Adolf visits L M Ericsson



His Majesty tries out LME's videophone.

King Gustaf Adolf and Earl Mountbatten of Burma with nephews Norton and Michael John Knatchbull, Prince Bertil and suite, visited L M Ericsson's head factory at Midsommarkransen on Monday, April 1. The visit was made at the request of the King himself.

The prominent visitors were received by Dr. Marcus Wallenberg, Chairman of the Board of L M Ericsson, and the President, Mr. Björn Lundvall.

After Mr. Lundvall had given an account of L M Ericsson's activities in Sweden and abroad and Dr. Christian Jacobæus had reported on the technical side, there followed a demonstration of some of the company's products in the exhibition room. The king and his guests were specially interested in two videophones which had been set up specially for their visit. The king conducted a video conversation with his brother-in-law Earl Mountbatten and with the seventeen-year-old Michael John Knatchbull.

After an hour or more with L M Ericsson the visitors continued to Tumba just outside Stockholm to see Sweden's first stored-programme-controlled telephone exchange. They were received by Mr. Bertil Bjurel, Director General of the Telecommunications Administration, who showed them round the exchange in the company of Messrs. Fred Sundqvist, Kurt Katzeff and Torbjörn Andersson, all of L M Ericsson.

H. R. H. Haile Selassie, emperor of Ethiopia, visited in February a telephone exchange delivered by L M Ericsson to Massawa. The photograph shows on the right of the Emperor, H. H. Ras Asrate Kassa and the Head of the Ethiopian P. T. T., Director General Ato Betru Admassie.

On March 20, during an inofficial visit to Sweden, the Chilean Minister of Home Affairs, Professor Bernardo Leighton, made a visit to L M Ericsson's head factory at Midsommarkransen. He was accompanied by his wife and by the Chilean Ambassador to Sweden, Dr. Edward Hamilton.

At L M Ericsson he saw the Exhibition Room and the Training Centre and made a short tour of the factory. The photograph is taken from the Exhibition Room with (from right) Prof. Leighton, Sra. Leighton and Dr. Hamilton.

Minister Arpad Kiss of the Department of Technology and Research in Budapest, Hungary, was in Sweden during the first week of April. On April 2 the Minister and his suite were the guests of L M Ericsson.

They were received by the management headed by the President, Mr. Björn Lundvall, and were given a survey of the aims for the company's engineering developments. In conjunction therewith a demonstration was given of the videophone. The photograph shows members of the group in the section for relay parts manufacture with (from left) the Hungarian Ambassador to Sweden, Mr. Ferenc Esztergályos, the Ambassador's Secretary, Mr Laszlo Szikra, and Minister Arpad Kiss.

Opening of L M Ericsson's International Guest Center

During May L M Ericsson arranged a showing to the press of its new International Guest Center situated close to the Head Factory at Midsommarkransen. It was built in order to provide a temporary residence for the telephone technicians from different parts of the world who every year are invited to the company to study L M Ericsson's techniques, systems and products.

The building is three floors high and contains 57 bedrooms of some 16 sq.m. each, three kitchens, a number of TV and common rooms, table-tennis room, a shower in each room, Finnish bath, laundry and individual lock-ups. In each room there is a radio, telephone and electric alarm clock. The building, including furnishing, cost 2.2 million kronor.

*

Since 1961, when L M Ericsson organized a special section within its Training Centre for the training of foreign telephone technicians, 800 students from seventy or so countries have come to Stockholm to take courses at the company's expense. This year 150 students are expected, including two female engineers, at the Training Centre in Stockholm.

Entrance of L M Ericsson's International Guest Center

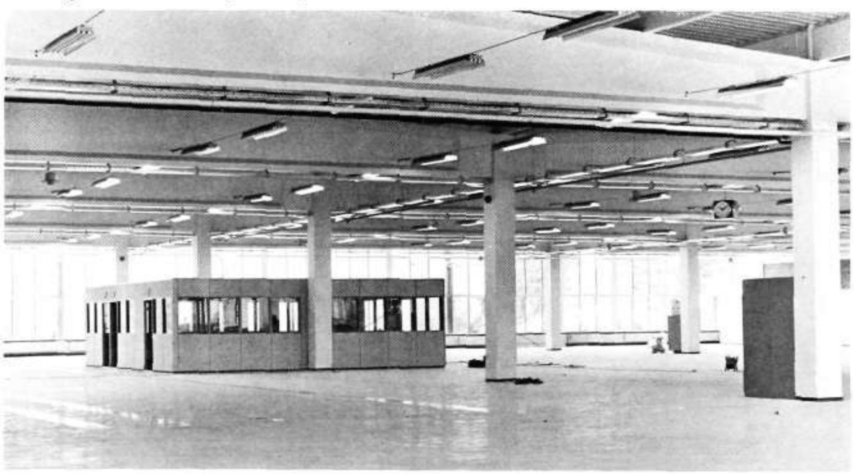
A/S Elektrisk Bureau's Hisöy Factory Completed

A/S Elektrisk Bureau, one of L M Ericsson's subsidiaries in Norway, can now move into its Hisöy factory, the second stage in the building of which is practically completed. It has cost about 7 million Swedish kronor and has a total area of 5200 sq.m., nearly five times as much as the present factory area.

The large hall of 4000 sq.m. enables the company to collect together all its departments under the same roof. A very advanced manufacturing organization can also be brought into effect, including two automatic testing machines. Elektrisk Bureau will be the first European subsidiary to have such machines.

When the new section of the factory is in full operation the number of employees will be around 220.

The large hall in the Hisöy factory.



ICT Leader in Giant British Group

The two leading suppliers of computers in the United Kingdom—International Computers and Tabulators Ltd. (ICT) and The English Electric Company Ltd—are to combine their activities as regards the manufacture and marketing of computers for administrative and scientific purposes by jointly forming a new company, International Computers Ltd. (ICL). The controlling interest in the new company will be held by ICT.

The agreement is subject to the approval of ICT's shareholders and—as regards the research grant—of parliament.

The Managing Director of ICT, Mr. A. L. C. Humphreys, will also be head of ICL.

*

L M Ericsson Data AB is Swedish General Representative for ICT's products within the computer field.

Representatives

Please turn page for list of associated and co-operating enterprises and technical offices

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Austria
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Allumage Lumière S.A. *Bruxelles* 7, 128-130, chaussée de Mons, tel: 22 98 70, tgm: allumalux, telex: 21582, "ALLUMALUX BRU"

Greece
Angelos Cotzias *Athens*, 18, Odas Omirou, tel. 626-031, tgm: cotziasan, telex: 252, "COTZIASAN ATHEN"

Iceland
Johan Rönning H/F *Reykjavik*, P.O.B. 883, tel: 10632, tgm: rönning

Spain
TRANSA Transacciones Canarias S.A., *Las Palmas de Gran Canarias*, Tomas Morales 38, tel: 21 85 08, tgm: transa, telex: 824, "MAVAC LPE"

Yugoslavia
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Myanma Export Import Corp., Agency Div. *Rangoon*, P.O.B. 404, tel: 146 18, tgm: myanimport

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Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

S.A. Petrides & Sons Ltd. *Nicosia*, P. O. B. 1122, tel. 2788, tgm: armature

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Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswede

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The Arab Trading & Development Co., Ltd. *Amman.*, P.O.B. 6141, tel: 25981, tgm: aradeve

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Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat telex: 048, "BEHBEHANI KURAIT"

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Constantin Georgiades, *Damas*, P.O. B. 2398, *tel: 266 73, tgm: georgiades*

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Transcandia Ltd. Telecommunications Division *Nairobi, Kenya*, P.O.B. 5933, tel: 27103, tgm: transcanda

Liberia
Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Streets, tel: 22222, tgm: radiolibe

Libya
ADECO African Development & Engineering Co *Tripoli*, P.O.B. 2390, tel: 33906, tgm: adeco

Mauritius
Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

Mozambique
J. Martins Marques & Ca. Lda. *Lourenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

Nigeria
I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531, tgm: consult, telex: 235, "SHELLBP LAGOS"

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Contomichalos, Sons & Co. Ltd. Engineering & Agencies Dept., *Khartoum*, P.O.B. 866, tel: 77 695, tgm: suconta, telex: 251, "CONTOLOS"

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Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

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Ateliers Mécaniques du SAHEL, *Sousse*, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

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GNT AUTOMATIC A/S *DK-2060 Søborg*, Telefonvej 6, tel: 69 51 88, tgm: automatic, telex: 5264. "AUTOMATIC KH"

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Centrum Electronic S. A. *Paris 17e* 32, Rue Legendre, tel: 267 30.10, tgm: centrumfrance

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Production Control (Ericsson) Ltd. *Twickenham Middx*, Regal House, London Road, tel: POPesgrove 8151, tgm: teleric

Centrum Electronics Ltd. *London S.W.I.*, tel: SLOane 0451, tgm: celefon telex: 2613, "CELEFON LDN"
Centrum Rentals Ltd. *London S. W. I.*, Terminal House, Grosvenor Gardens, tel: Sloane 0451, tgm: celefon, telex: 2613, "CELEFON LDN"

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SETEMER, Soc. per Az. *I-00198 Roma*, Via G. Paisiello 43, tel: 868.854, tgm: setemer

SIELTE, Soc. per Az. *00100 Roma*, C. P. 5100, tel: 577 8041, tgm: sielte

Netherlands

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Voorburg-Den Haag, P.O.B. 3060, tel: 81 45 01, tgm: erictel-haag, telex: 31109, "ERICTEL DENHAAG"

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A/S Elektrisk Bureau *Oslo 3*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 1723, "ELEKTRIKEN O"

A/S Industrikontroll *Oslo 6*, Grenseveijen 86/88, tel: Centralbord 68 34 64 tgm: indtroll

A/S Telesystemer *Oslo 6*, Tvetenveien 32, Bryn, tel: 68 72 00, tgm: telesystemer, telex: 6900, "ALARM OSLO"

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AB Ermi *Karlskrona 1*, tel: 0455/230 10, tgm: ermibolag, telex: 4819, "ERMI KKR"

AB Rifa *Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308, "ELRIFA STH"

Instruktionsteknik AB, *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec

L M Ericsson Data AB *Solna*, tel: 08/83 07 00, tgm: ericdata, telex: 10 93, "ERICDATA STH"

L M Ericsson Telemateriel AB, *Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00 tgm: ellem, telex: 1275, "1275 TELERGA S"

Sieverts Kabelverk AB *Sundbyberg*, tel: 08/28 28 60, tgm: sievertsfabrik, telex: 1676, "SIEVKAB STH"

Svenska Radioaktiebolaget *Stockholm 12*, tel: 08/22 31 40, tgm: svenskradio, telex: 10094, "SVENSKRADIO STH"

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Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02 tgm: ellemist

Izmir, Izmir Bürosu, Kisilkaya Han, Kat 3. No 13, Halit Ziya Bulvari, tel: 378 32, tgm: ellemir

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Deutsche Ericsson G.m.b.H. Telematerial, *4 Düsselorf-Rath*, Postfach 136, tel: (0211) 63 30 31, tgm: erictel, telex: 8586871, "8586871 ERIC D"

Centrum Electronic G.m.b.H. *3 Hannover*, Dornierstrasse 10, tel: 63 10 18, tgm: centronic, telex: 922913, "922913 CELEC D"

• ASIA •

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India

Ericsson Telephone Sales Corporation AB *Calcutta 22*, P.O.B. 2324, tel: 45 44 94, tgm: inderic

New Delhi 16, L25, South Extension Part II, tel: 626505 tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Ir. H. Djuanda 151—153, tel: 8294, tgm: javeric

Djakarta, Djalan Gunung Sahari 26, tel: OG 48531, tgm: javeric

Iraq

Telefonaktiebolaget L M Ericsson, Technical office *Baghdad*, P.O.B. 493, tel: 914 54, tgm: ellemco

Kuwait

Telefonaktiebolaget L M Ericsson, Technical office, *Kuwait*, *State of Kuwait*, P. O. B. 5979, tel: 26 855, tgm: erictel

Lebanon

Telefonaktiebolaget LM Ericsson, Technical office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 252627, tgm: ellem, telex: 876, "ELLEM BERYT"

Malaysia

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Singapore

Ericsson Telephone Co. Private Ltd. *Singapore 1*, P.O.B. 3079, tel: 943 62, tgm: sineric

Thailand

Ericsson Telephone Corp. Far East AB *Bangkok*, P.O.B. 824, tel: 58041-43 tgm: ericsson

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CONTENTS

On cover: Printed circuit card in the transfer unit of L M Ericsson's stored program controlled telephone exchange system AKE. The photograph is from the Tumba automatic exchange.

Stored Program Controlled Telephone Exchanges — a Milepost in the Development of Telephony

C. JACOBÆUS, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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On the morning of April 21, 1968, 5000 subscribers in Tumba outside Stockholm were cut over from the previous 500-line selector exchange to a new stored program controlled exchange type AKE. The first stored program controlled exchange manufactured by L M Ericsson had thereby been put into service.

The stored program controlled exchanges represent a milepost in the history of switching technique – perhaps the most significant since the introduction of automatic exchanges. This article presents a survey of the technical developments which have led up to this new achievement.

The purpose of telephone exchanges may be said to be to interconnect subscribers in order that they may conduct conversations. Every subscriber must be connectable to any other subscriber. The exchanges must also be able to change the interconnection pattern whenever the subscriber desires, either for a new circuit or through the removal of an existing circuit. In contradistinction to the changeability desired in the exchanges, the main interest in the transmission media, which are permanently established, is in economy, often through different forms of multiple utilization.

In the course of its development switching technique has attracted the interest of many ingenious brains. They have perhaps had more free play for their imagination than in other fields, since there has been no international standardization. Likewise, switching technique is by nature combinatorial, which makes the possibilities multifaceted. There are nevertheless certain basic functions which in one form or another reappear in all switching systems. The developments leading up to the stored program controlled systems have in many respects followed a logical course. A survey of the history of switching technique shows how it has been possible to materialize the basic functions in different ways and how this has led up to the stage which we have now reached, namely the stored program controlled exchanges.

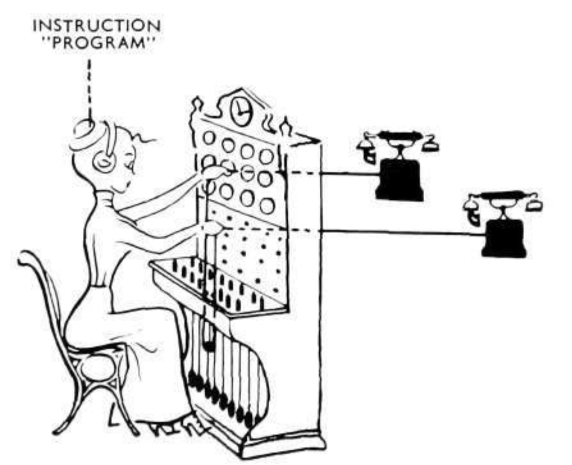


Fig. 1
Manual system

Manual Exchanges

Let us take a look at the manual exchange, or perhaps rather the manual system, i.e. the exchange with operator, from the general point of view. We shall gain assistance from the computer technicians who, in the study of their own technique, have introduced two concepts, memory and logic, which are also the cornerstones in telephone switching technique. In the manual system the memory and logic exist both in the equipment and in the operator. One may say that the memory represents the state of the switching equipment, while the logic dictates how the state must be changed under the influence of external signals. Purely concretely, of course, there is the memory of the operator, who remembers the number requested by the calling subscriber.

The equipment also has memory functions. By being connected, one may say that a cord pair memorizes the subscribers which it connects. When the clearing signal comes in, a clearing signal lamp on the cord pair lights. The cord pair will thus remember that the clearing signal has been issued by the conversing parties. An analysis shows that all units which can assume more than one state–in a manual exchange the cords, relays, clearing signal units etc.–have a memory function.

The logic exists both in the equipment and in the operator. As an illustration of what is meant by logic, one may take precisely the clearing signal function in a *C. B.* system. A clearing signal can be obtained in four different ways:

1. When the *calling* party releases
2. When the *called* party releases
3. When either or both subscribers release
4. When both subscribers release.

Fig. 2 shows a transmission bridge with the alternative forms of clearing signal. The "logic" in the equipment says what must be done when an external change takes place. In case 4–last party release–the clearing signal thus comes when both parties have hung up, while on the other hand nothing happens when only one subscriber hangs up. It may be added that the clearing signal function is in principle the same in an automatic exchange.

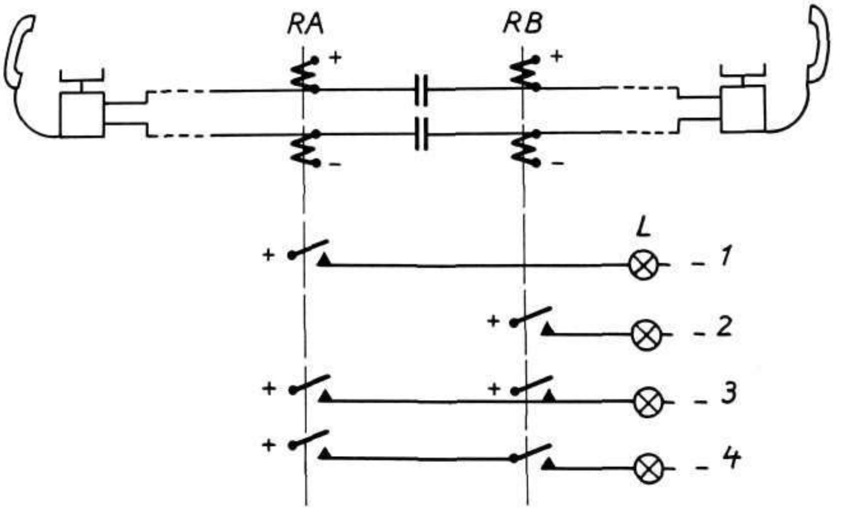


Fig. 2

Clearing signal function in C.B. system

RA	Feed relay, sub. A	
RB	" " , sub. B	
L	Clearing signal lamp	
1.	Clearing signal when	A releases
2.	" " "	B "
3.	" " "	A or B releases
4.	" " "	A and B release

The operator also learns certain logical functions. She answers a call, for example, when a call lamp lights, she takes down the connection when the clearing signal lamp on the cord lights, and so on. The logic function of the operator is in fact identical with the procedure she has been instructed to follow or, to use once again a computer concept, the program she has learnt in order to discharge her task. The operator may naturally go beyond her instructions by using her judgment in unforeseen situations. She may thus assist unaccustomed subscribers, she perhaps learns the numbers of subscribers who receive large numbers of calls so that they can be called by name instead of by number, and so on.

A comment may here be in place. In a telephone exchange all logical patterns can be realized, i.e. the limitation which exists as regards the functioning or the working routines of exchanges is due solely to the fact that conflicting conditions cannot be fulfilled.

The Strowger Systems

The first automatic systems used step-by-step selectors working on the decimal principle. In a large exchange there was a chain of selector stages, and a number of selectors in series were used on a connection between a *calling* and *called* subscriber. The selectors were operated by relay sets. The selectors with their relay sets constituted the memory and logic units of the system. The logic functions existed for the most part in the build-up of the relay sets. Characteristic of these systems is that the logic, and so the functioning of the exchanges, is dependent on a number of units, admittedly of a limited number of types but dispersed throughout the entire exchange complex. Every selector in the system is equipped with a relay set. On economic grounds these relay sets must be fairly limited in their function. These exchanges therefore have little scope for variation in their working routines. This is especially noticeable in a multi-exchange network, in which the direct-driven systems involve certain limitations. A change in the mode of operation of the exchange requires alterations of all logic units concerned, which makes such a change troublesome and expensive.

Automatic operation was hardly an economic proposition from the start. The advantages of automatization did not become manifest until the 20th century. In the Strowger systems, however, they were bought at the price of a service with more limited facilities for variation and less flexibility in respect of development. The positive and negativ characteristics of the human factor become very evident in this context.

Register-Controlled Systems

The discovery of the register introduced a new era in switching technique. Several thoughts lay behind this new feature. Chief among them probably was that the step-by-step selectors had been found to have disadvantages in respect of maintenance and utilization. Selectors with other drive arrangement

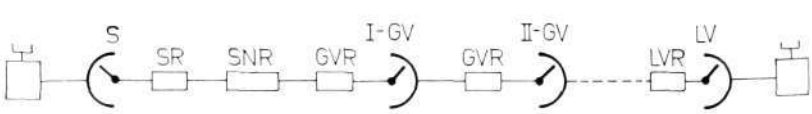


Fig. 3

Strowger system

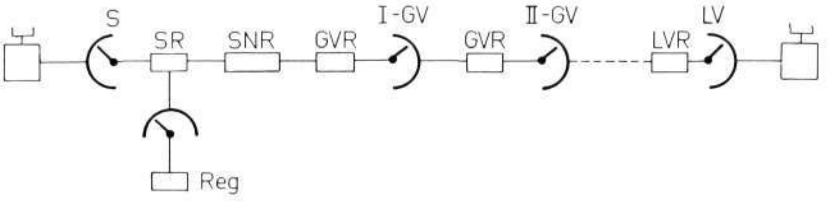
S Line finder
GV Group selector
LV Final selector
SR Finder relay set
SNR Cord circuit relay set
GVR Group selector relay set
LVR Final selector relay set
(SNR, GVR, LVR: Logic and memory units)

Fig. 4

Register system

S Line finder
GV Group selector
LV Final selector

Reg Register
SR Finder relay set
SNR Cord circuit relay set
GVR Group selector relay set
LVR Final selector relay set
(Reg, SR, SNR, GVR, LVR: Logic and memory units)



than a stepping mechanism could be made more reliable. A saving could also be effected on selcetors and relay sets by abandoning the decimal structure. The registers received the pulses dialled by the subscriber and converted them into other signals which could direct new "machine-driven" selectors with larger capacity than the decimal type. This implied that these signals were electrically different from the dial pulses. The decimal structure of the number was replaced in the register by a numerical system based on other numbers than 10, namely on the numerical parameters of the selector used.

The registers proved to have a profound influence on switching technique. The chief point perhaps was that the functions used during the setting up of a connection were concentrated to a smaller number of units. Without loss of economy it was thus possible to satisfy more complicated conditions for the functioning of the exchanges. This was of special significance in multi-exchange networks. The register technique is in general a prerequisite for automatization of trunk traffic. Registers were often introduced, too, in systems with decimal selectors. Another important advantage of registers is that changes in the lay-out of the network, caused for example by the addition of new exchanges, can be quite easily carried out as they affect only a small number of units. The logic could often be more easily adapted to the development requirements during the life of the exchange.

Marker Systems

The marker systems represent a further step on the road to a more concentrated arrangement of the logic functions of an exchange. The marker was originally developed probably in order to be able to control switching networks with link systems. The various switching stages in such a system are interdependent, which makes it necessary to have a common unit which can supervise the state of the switching network and then select a switching path. Again it was primarily economic considerations which underlay the introduction of the marker technique. Crossbar switches, which have many advantages from the manufacturing and maintenance points of view, must be grouped into link systems and controlled by markers in order to produce competitive exchanges.

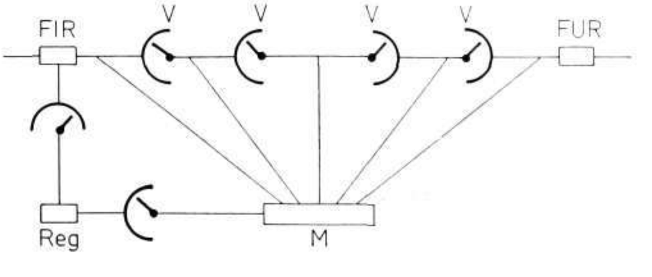


Fig. 5

Marker system (transit exchange)

V Switch
FIR Junction relay set, incoming
FUR " " ", outgoing
Reg Register
M Marker
(FIR, FUR, Reg, M: Logic and memory units)

As in the case of registers, it proved that the markers could be entrusted with other tasks than the functions necessitated by the switches. The markers often took over from the registers the translation and traffic routing functions. Traffic measurement can be done from the marker, as also fee determination. Few markers were required in an exchange, as they are used during a period of less than one second on each call. They could thus be made voluminous without loss of economy and so be given a richly differentiated logical function. Nor were changes in the working routines of exchanges so costly, as only a few units were concerned.

Stored Program Controlled Exchanges

The developments leading up to the stored program controlled exchanges have thus been characterized by a successive concentration of the logic functions in the exchanges to a few units, at the same time as it has been possible to give the exchanges an increasingly diversified function and an increasing flexibility to meet new requirements. In the marker exchanges, however, a large number of the logic functions are still dispersed among many units in the exchange, i.e. the functions in cord circuit relay sets and junction line relay sets. These are functions which relate to the seizure and release of circuits connected to the exchange, and the exchange of signals necessitated thereby. Especially in trunk exchanges the logic units are large and numerous. Here there is still the disadvantage that changes in signalling conditions (which are not unusual) involve alterations in all relay sets concerned.

In electronically controlled exchanges the logic functions which previously existed in cord circuits and junction relay sets have also been concentrated to the central control units. In cord circuits and junction line relay sets there are now units – electromagnetic or electronic relays – solely for sending and receiving of signals. It is the electronic design of the central control units that has enabled these units to work at so high a speed that they can deal with all changes in signalling states on the lines. At the same time a concentration of the memory functions has been arranged in these exchanges. This may be regarded, however, solely as a new way of arranging the memory units. It does not reduce their number. Nor would this be possible; the saving arises from the fact that, through the concentration, the memory function can be solved in a less expensive way.

Electronic control of exchanges with concentrated logic and memory functions may perhaps be regarded as an advance over the earlier exchanges based on electromagnetic technique. The advantages from the technical and economic aspects, however, are slight. Electronics does, however, permit the introduction of *stored program control*. This implies that the logic functions previously existing in relay sets, registers, markers, etc. are now controlled by a program read into a memory. The program determines the working routines of the exchange. If a change is required in an exchange function, e.g. owing to the introduction of a new signalling system or a new traffic facility, this is done by writing a new program into the program memory.

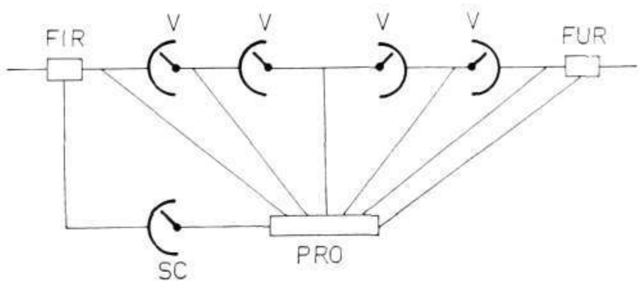


Fig. 6

Stored program controlled system

V Switches
FIR Signal receiving and signal sending unit, incoming
FUR Signal receiving and signal sending unit, outgoing
SC Scanner
PRO Processor

The introduction of stored program control was the final step in the long development towards a successively greater concentration of the logic functions to a few units. At the same time it may be said to relate back to some extent to the birth of telephony, namely the manual telephone system. The program input naturally corresponds to the learning by the operator of her instructions. In the same way as an operator can be given a new working routine, so can a stored program controlled exchange in the form of a new program. Stored program control combines with the flexibility of the operator in dealing with new conditions its very much greater speed of working – naturally a trivial point – but above all its far more diversified repertoire.

Stored program control permits very much more diversified working routines in the exchange. The possibilities of variation are actually limited only by the capacity of the program memory. For a small extra cost, therefore, new traffic facilities for the subscribers can be introduced, such as abbreviated dialling enquiry and transfer, ring-back on busy etc. It also becomes possible to draw up programs for fault tracing which facilitate the maintenance of the exchange.

The stored program controlled exchanges are a milepost in the development of telephony. The earlier successive concentration of logic units to register and marker etc. was to a large extent a question of improvements in the known technique. Solutions of logical problems in relay sets have necessarily followed the same lines. Stored program contral opens up an entirely new path in automatic telephony, in that the physical realization of the logic functions has now been replaced by written rules read into a memory. From the point of view of equipment design and manufacture this is of great significance, but the really radical change is for the telephone technicians themselves. All relay-based solutions are now replaced by programs. This will mean a new way of working both for designers and maintenance people.

Stored program control is competitive at present only for large units with complicated traffic conditions. The central control units are expensive and therefore require a large volume of traffic in order to be competitive. It may also be expected that, for the expansion of plant which is not too obsolete, administrations will continue with the system they already possess. As new experience is gained of stored program control and new advances are made within memory and circuit technique, its economic field will be widened. There is no doubt that in the long run the great majority of exchanges will be stored program controlled. Other tendencies, e.g. towards electronics also for the switching network, or digital integrated systems, will not change this picture. Stored program control will be the predominant solution for the logic functions within automatic telephony in the future.

The Tumba Stored Program Controlled Telephone Exchange

K KATZEFF & T ANDERSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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As described earlier in this issue of the Ericsson Review, the Tumba Stored Program Controlled Telephone Exchange was put into service on the 21st of April 1968. As the exchange represents a new approach in telecommunication techniques the following article gives a rather detailed description of the methods employed. It should be pointed out that the Tumba Exchange functions on the single Processor System. This means that the data handling unit can only contain one pair of computers. Future installations will be of the multi-processor system type which allows several pairs of computers to be connected, thereby increasing the traffic handling capacity of the entire system.

System Build-up

The Stored Program Controlled System AKE 120 which uses the code switch as a connecting element in the speech circuits comprises the following three functional units, see fig. 1:

Telephony unit TE
Transfer unit FE
Data processing unit DE

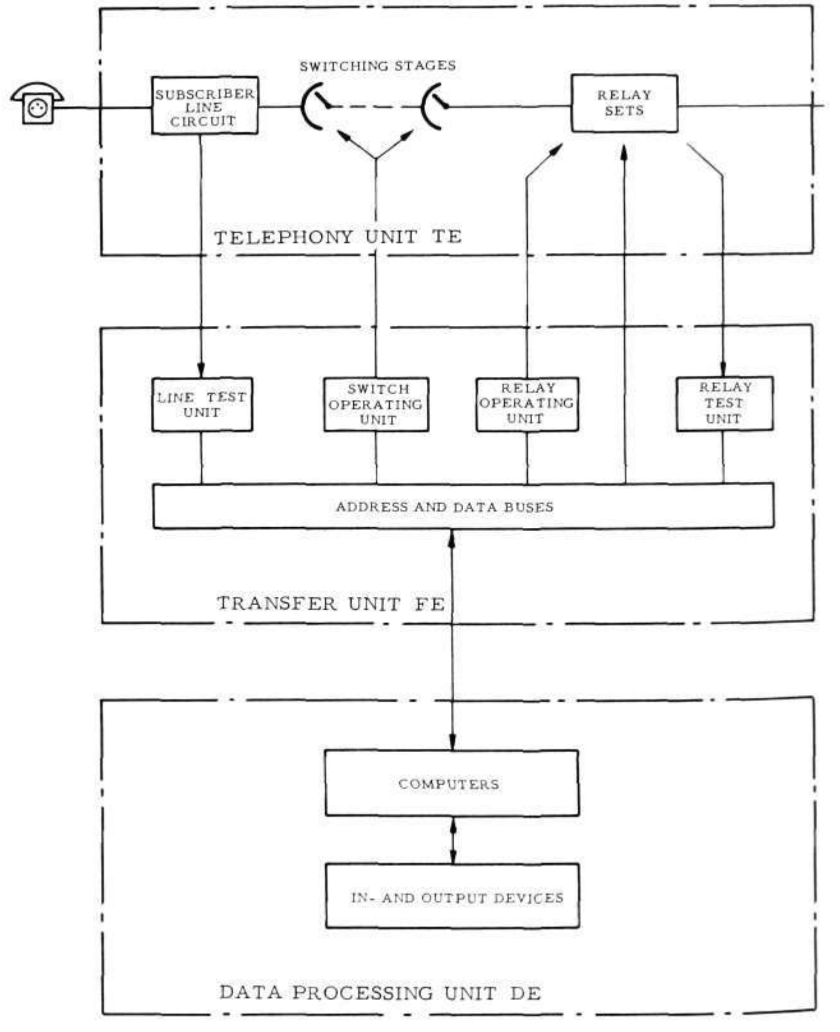


Fig. 1
Block Diagram of the AKE System

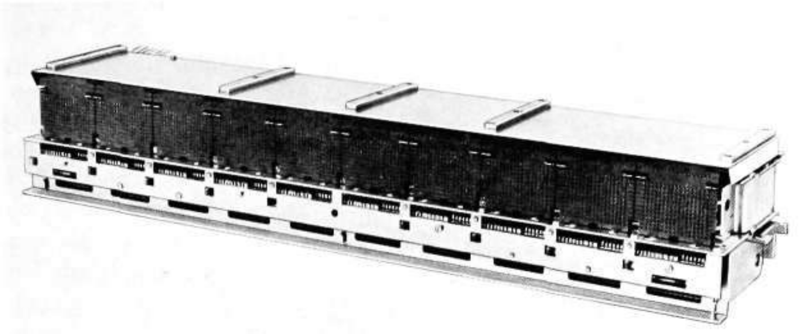


Fig. 2
The Code Switch

In order to present a general picture of the fundamentals of the AKE system each of these units is first described in outline. This description is followed by a more detailed description later on in the article.

The Telephony Unit

The telephony unit contains code switches, fig. 2, connected in accordance with the link principle, as described in more detail in Ericsson Review No 3, 1964, fig. 2, as well as relay sets which do not contain any logic performing, storing, timing, or conversion functions, as these have been concentrated to the data processing unit. The relay functions have thus been reduced to the simple generation and detection of signals. The data processing unit scans the contacts of the signal receiving relays and operates the signal transmitting relays in accordance with programs stored in it. This results in only a few types of unsophisticated relay sets being required. Markers and registers, as used in conventional link systems are thus no longer required since their functions have been even more concentrated and have now been taken over by the data processing unit.

The Transfer Unit

The transfer unit acts as an adapter between the telephony unit and the data processing unit. It enables the data processing unit working at micro-second speed to interwork with the code switches and telephone relays of the telephony unit whilst at the same time fully utilizing the speed of the data processing unit. The transfer unit contains a number of electronic circuits of the gate and flip-flop type containing silicon semi-conductors. The interface equipment, which adapts the transfer unit towards the telephony unit contains reed relays and ordinary telephone relays.

The Data Processing Unit

The controlling unit of the AKE 120 consists of a data processing system APZ 110 designed by L M Ericsson operating on real time basis, and which contains two computers each consisting of a central processing unit, a program store and a data store. The duplication of the computers has been considered necessary in order to ensure the outstanding operational properties of the system. The circuits are electronic and contain semi-conductors of silicon type. As memory elements ferrite cores are used.

An analogy with manual telephony exists, as the computer can be compared with a single very qualified telephone operator, centrally placed and with high working capacity for carrying out the following tasks:

- The answering of calls
- The receiving of the required digit information
- The performing of test functions to ascertain whether the required number is free or occupied
- The selecting of a free switching path and the setting up of the connection
- The supervision (the scanning) of conversations set up in order to perceive end-of-call signals

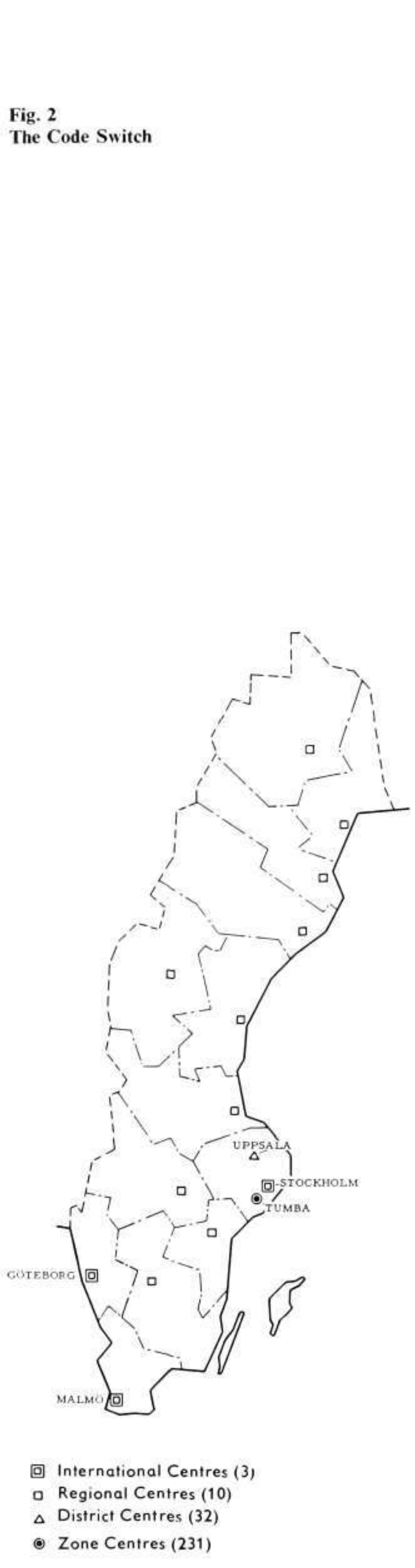
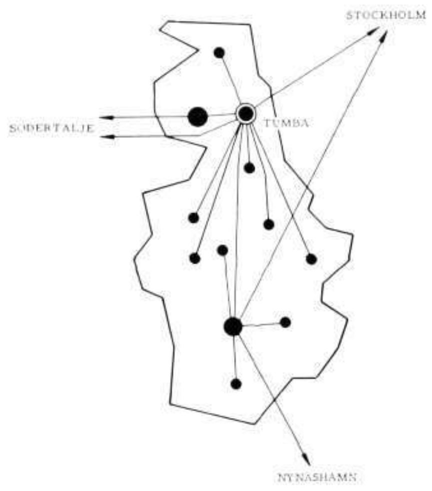


Fig. 3
The Principal Telephone Areas of Sweden, showing the Tumba Zone. See also fig. 4.



Legend:

Zone Centres

Group Centres

Terminal Exchanges

Fig. 4
The Tumba Area

- The noting of the conversation time and preparing of call charging information
- The supervision and transmission of alarms in case of faults or blocking

Both computers operate in parallel and synchronously treat the same data. The exact similarity of both results is continuously checked by a supervisory unit. Any eventual difference is discovered and the supervisory unit then starts a fault localizing rotuine, blocks the faulty sub-unit and prints out a fault report on a type writer. The computer found faulty thereafter shares the corresponding fault free sub-unit with the other computer until the fault has been repaired. In this manner several faults can occur without impairment of the traffic handling capacity of the exchange.

The programs are stored in ferrite core memories, which form an important part of the computer. The same computer can be used in different executions of the AKE system and only the size of the stores and the programmed information varies in different installations. A main program administers a number of sub-programs. The sub-programs carry out the standardized functions which reoccur in different AKE exchanges.

Special Subscriber Services

In addition to the services normally offered by a conventional electromechanical telephone exchange the following special subscriber facilities have been introduced in Tumba in order to provide the Swedish Telecommunications Administration with the possibility to test these facilities and to form an opinion on their future value.

Abbreviated calling, which means that a subscriber who frequently calls certain other subscribers only has to dial short code digits instead of the complete directory numbers of those subscribers.

Follow me, which means that a subscriber temporarily can have all the calls coming to him automatically transfered to another instrument.

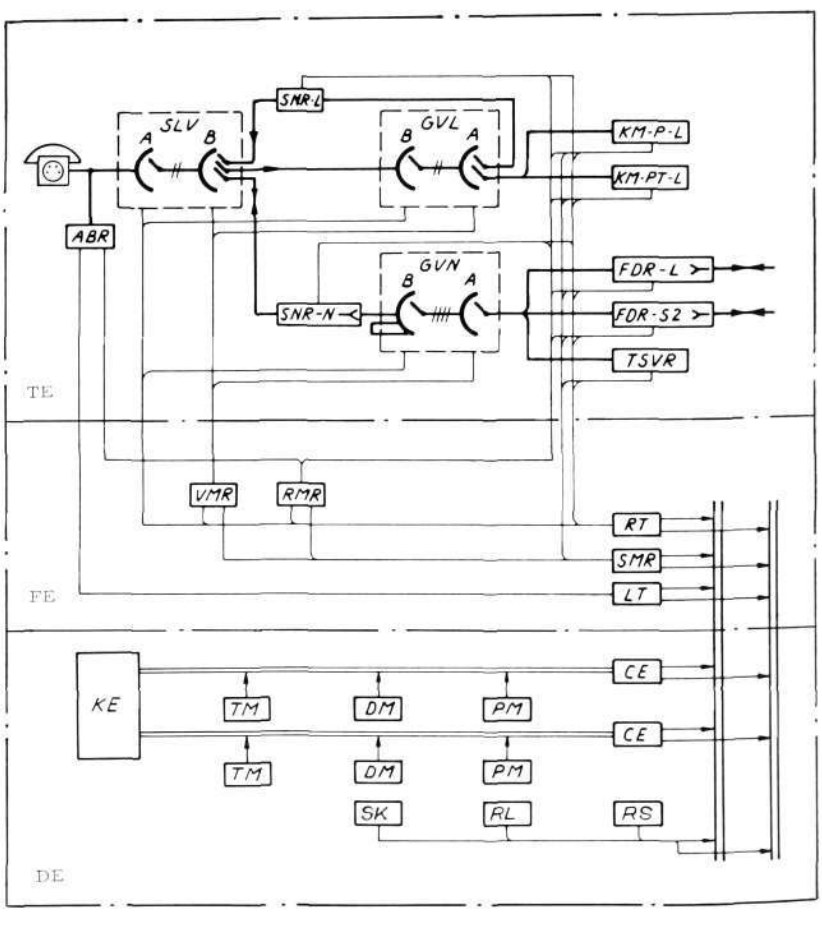


Fig. 5
Traffic Route Diagram showing link-up with the Data Processing Unit.

SLV	Subscriber Stage
GVL	Local Group Selector
GVN	Trunk Group Selector
ABR	Subscriber Line Circuit
SNR-L	Local Link Circuit
SNR-N	Trunk Link Circuit
KM-P-L	Code Receiver, Dial
KM-PT-L	Code Receiver, Pushbutton
FDR-L	Junction Line-DC
FDR-S2	Junction Line-S2
TSVR	Telephone Answering Machine
VMR	Switch Operating Unit
RMR	Relay Operating Unit
RT	Relay Test Unit
SMR	Buffer Store
LT	Line Test Unit
CE	Central Processing Unit
PM	Program Store Unit
DM	Data Store Unit
TM	Table Store
KE	Supervisory Unit
SK	Type Writer
RL	Tape Reader
RS	Tape Punch

Alarm Clock Service, which means that the subscriber has the possibility to register in the exchange the time of day or night at which he wishes to be called. For this registration the subscriber dials four digits in accordance with the international 24-hour cycle.

Call back, means that the subscriber who has dialled the number to a busy subscriber dials a further code digit and replaces his handset. He is then called back automatically as soon as the busy subscriber has become free.

Transfer on busy, means that a call incoming to a busy telephone is automatically transfered to a free telephone in accordance with a call transfer list.

In addition to the possibility of introducing the above mentioned subscriber services the Tumba Exchange is prepared for the future introduction of other additional facilities.

The Tumba Traffic Routing

The group centre of Tumba is a combined local and transit exchange connected to the Stockholm trunk exchange. It also has direct routes to neighbouring trunk exchanges. Six terminal exchanges and two group exchanges are ranked under Tumba. In order to illustrate the Tumba zone in relation to the entire telephone network of Sweden fig. 3 shows Sweden divided up into the different regions. Fig. 4 shows the Tumba zone.

Fig. 5 shows the switching paths in the Tumba exchange as well as the previously mentioned main units e.g. the telephony unit (TE), the transfer unit (FE) and the data processing unit (DE).

Below follows a more detailed description of these three units.

The Telephony Unit TE

Switching Stages

The subscriber stage SLV consists of link connected partial stages A and B. It is built up in groups of 1600 lines in units of 200 lines each.

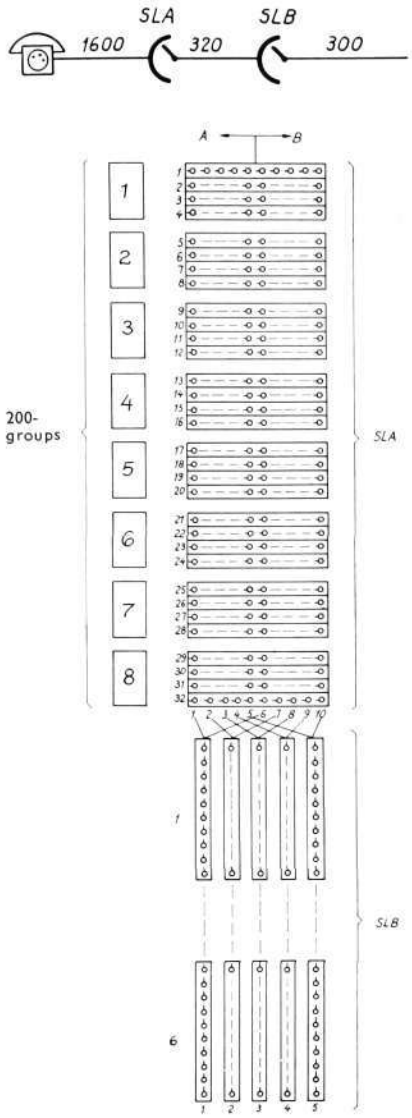


Fig. 6
Subscriber Stage SLV

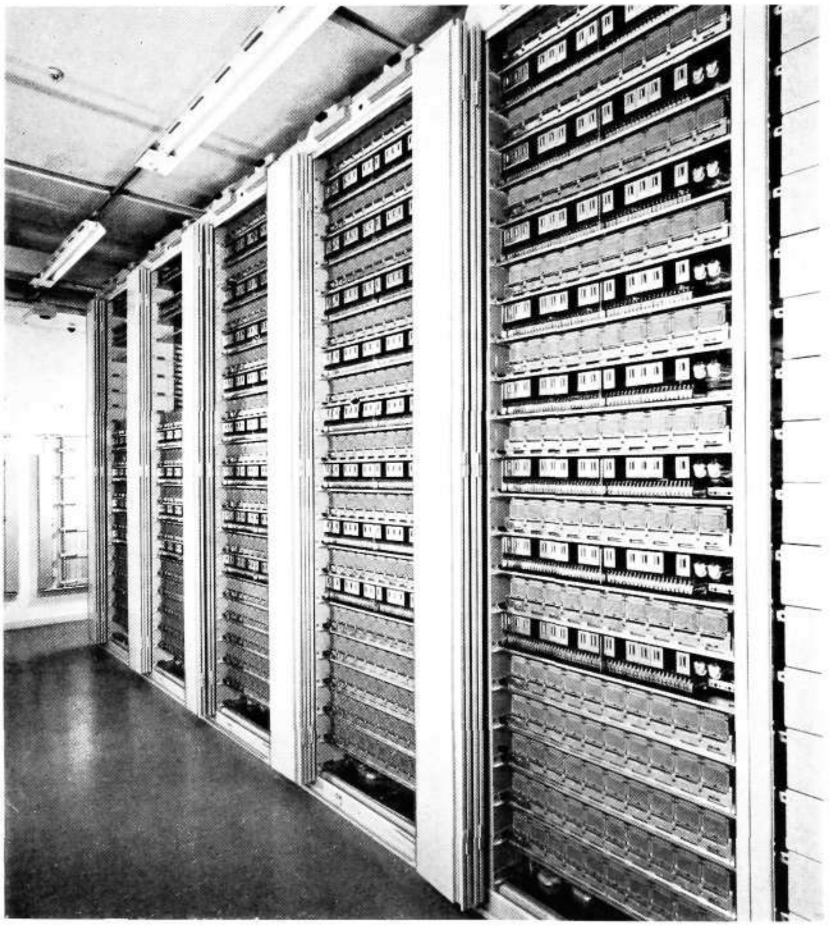


Fig. 7
Switch Racks in the Telephony Unit

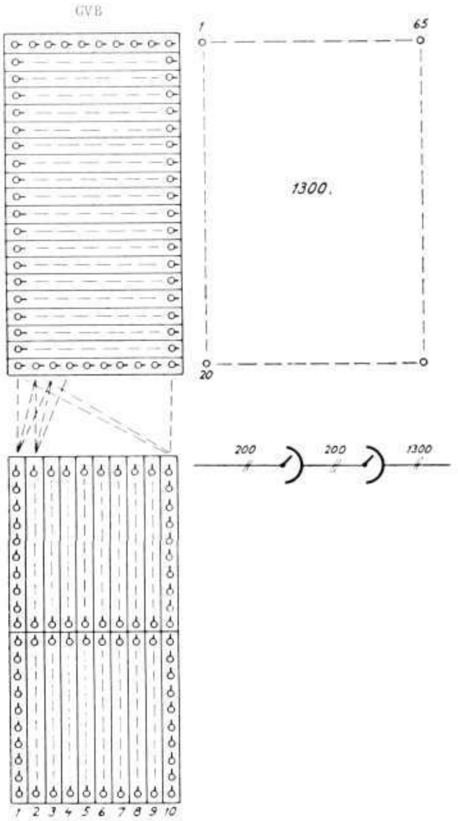


Fig. 8
Group Selector Stage GVL

As open numbering is inherent in the AKE 120 system the numbering is independent of conventional grouping. The grouping is shown in fig. 6.

The *SLA*-switch is a three pole switch with a multiple capacity of 52. One outlet is used for indication of the home position and one for test numbers. The remaining 50 outlets are used for the connection of subscriber lines. Two poles in the switch are used for a- and b-wires whilst the third is connected to the subscriber line relay set, *ABR*, in order to operate the cut-off relay of the subscriber. No metering wire exists, as the metering of conversations is done by the data processing unit by adding one to the contents of a call metering word, one metering word being provided in the data store for each subscriber.

The *SLB*-switch is a two pole switch. Of the possible 66 outlets 64 are utilized. One *SLB*-switch has access to two verticals in each *SLA*-switch. A fully built up group consists for m = 10 of 32 *SLA*- and 30 *SLB*-switches. In Tumba only 25 *SLB*-switches are required for each group. Fig. 7 shows the switch racks of the subscriber stage.

The local group selector stage GVL consists of two link connected partial stages A and B. The stage is built up in units of 200 inlets up to a maximum size of 1200 inlets per group. It is a two pole stage and in the *A*-vertical 60 outlets are utilized which reach three columns in the *B*-stage with 20 verticals per column. The *B*-vertical utilizes 65 outlets, thereby a total of 20 × 65 = 1300 outlets is obtained. The grouping is evident from fig. 8.

The Transit Group Selector Stage GVN consists of two link connected partial stages A and B. The stage may be extended in groups of 400 inlets and 800 outlets. It is a four pole stage, but permits connection of 4-wire-terminated 2-wire circuits as is the case in Tumba. The grouping is evident from fig. 9. Of the 42 possible outlets per vertical 40 outlets are utilized. In the A-stage these can reach two B-columns having 20 verticals per column.

Relay Sets

Subscriber circuit relay set ABR contains circuits which can be compared with conventional line and cut off relays.

Junction line unit FDR-S2 is a two-way unit and is intended for junction lines with balanced current pulse signalling. It uses 2-wire termination towards the line side and has 4-wire switching for connection onto the *GVN*-stage. Padding can automatically be connected into or out of the circuit.

Junction line relay set FDR-L is a two-way relay set and is intended for junction line circuits using DC-signalling. It is connected in the same manner as FDR-S2.

Cord circuit SNR-L is a one-way cord circuit and is intended for local traffic.

Cord circuit SNR-N is a two-way cord circuit and is intended for both subscriber controlled and operator controlled transit traffic.

Code receiver KM-PT-L is intended for use on subscriber circuits from When the code receiver has been connected over *SLV* and *GVL* it transmits dialling tone to the A-subscriber and thereafter detects the dial pulses.

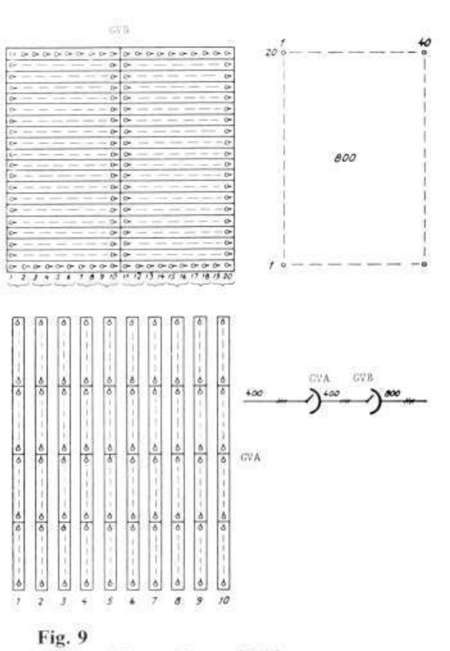


Fig. 9
Group Selector Stage GVN

Code receiver KM-PT-L is intended for use on subscriber circuits from which the digit transfer is either carried out solely by means of a key sender or by both key sender and ordinary dial. It can thus receive voice-frequency pulses as well as DC-pulses. During voice-frequency pulsing each digit is represented by two frequencies, each selected from a group of four different frequencies.

The telephone answering relay set TSVR transmits different tones and messages. It can connect up to a maximum of ten different telephone answering machines each capable of transmitting its own type of message.

The Transfer Unit FE

Survey

The purpose of the transfer unit is to enable the exchange of information between the telephony unit and the data unit. After having been ordered by the data unit to do so, it scans the state of the subscriber circuits and contacts in the telephony unit, after which the result is transfered to the data processing unit in the form of a binary number for the further treatment.

Thus the data processing unit is informed about changes in states caused by the subscribers of the own exchange or by other exchanges. Relays and switches in the telephony unit must be operated and the transfer unit thereby translates the binary coded operating orders to suitable operating voltages for the indicated relays and switches.

The scanning of the existing conditions is carried out over so called test matrices, which consist of two types e.g. matrices for subscriber line test *LT* and for relay test *RT*. Each subscriber line circuit in *ABR* is connected to an *LT*-point and a contact on each signal receiving relay to an *RT*-point.

Operation is carried out over operational matrices *SMR*, which directly control the signal sending relays and other relays with stringent time requirements. Remaining relays as well as the code switches are operated by *SMR* over secondary equipment in the transfer unit, i.e. the *RMR* for relay operation and the *VMR* units for the operation of switches.

A group of 16 test- or operational points corresponds to one word, which corresponds to the word length in the data processing unit which is 16 bits. The data processing unit treats 16 bits in parallel and has memories which are organized in words containing 16 information bits. The data processing unit treats the transfer unit as a store.

All information transfer between the telephony unit and the transfer unit is carried out over the above mentioned *LT*-, *RT*-, *SMR*-, *RMR*- und *VMR*-points. The transfer unit cooperates with the data processing unit over signal distribution circuits or buses. A bus of this type consists of a cable with several conductors for the parallel transfer of digital signals.

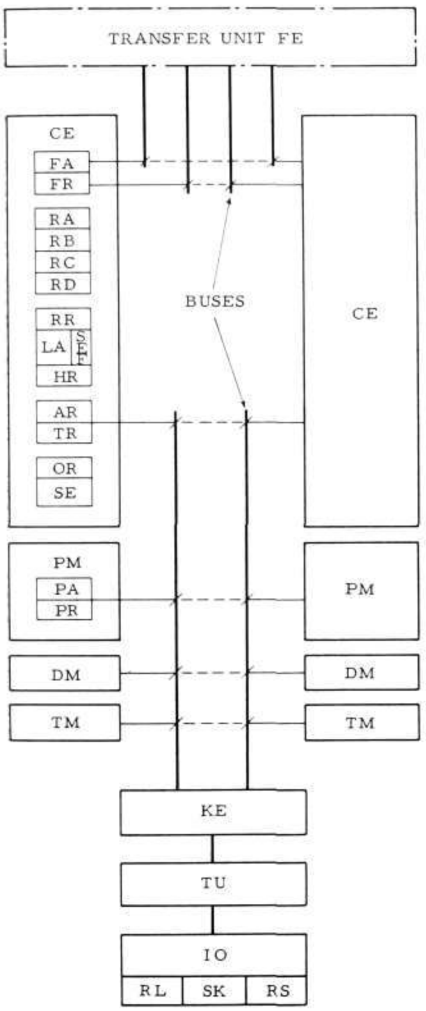


Fig. 10
The Data Processing Unit, DE

FE	Transfer Unit
CE	Central Processing Unit
FA	Address Register
FR	Result Register
RA	Logic Register
RB	Logic Register
RC	Logic Register
RD	Logic Register
RR	Result Register
LA	Arithmetical Unit
SEF	Indicator Flip-flop
HR	Auxiliary Register
AR	Accumulator Register
TR	Transport Register
OR	Operational Register
SE	Control Unit
PM	Program Store
PA	Program Store Address Register
PR	Program Store Result Register
DM	Data Store
TM	Table Store
KE	Supervisory Unit
TU	Maintenance Unit
IO	In- and Output Unit
RL	Tape Reader
SK	Type Writer
RS	Tape Punch

Interoperation with the Data Processing Unit

The buses between the data processing unit and transfer unit are transformer coupled while between the racks within the transfer group they are direct coupled. From an operational reliability point of view all buses are duplicated.

The transfer of signals to and from the data processing unit is acomplished over two registers for binary digits in the central unit called the address register *FA* and the result register *FR*, see fig. 10. The address bus is connected to *FA* whilst the test bus and the *SMR* data bus are connected to *FR*. The other end of the buses is connected to the partial decoder in *FE*, in which the recoding of the transfered binary information within each respective transfer group is carried out. The direct coupled buses are connected to bus units in each rack within the transfer group.

The signals between the data unit and the transfer unit contain addresses and control information. Each binary address can indicate a word in the transfer unit. The addresses are always sent out towards the entire transfer unit. Hereby only the receiving address unit which has the correct address code is actuated. The result hereof is that paths are opened for the transfer of data to or from *FR*.

During scanning operations the data unit transmits the test address and the clock pulse to the transfer unit. The address indicates which 16 test points are to be scanned and the clock pulse indicates when the scanning is to take place.

Fig. 11
Printed Circuit Card in the Transfer Unit

The transfer unit transmits the test reply and the check bits back to the data processing unit. The check bits indicate whether the test has been properly carried out.

During operating phases the data processing unit transmits first the *SMR*-address and clock pulse and thereafter the *SMR*-data, which switches the 16 flip-flops in the *SMR*-word to the desired states, zero or one. The one position results in the corresponding relay in the telephony unit being energized.

Test Matrices

The matrices for the line test *LT* and relay test *RT* each contain 1152 test points, which are arranged in 72 words with 16 points in each. A matrix consists of address circuits, test points and bit amplifiers.

The address circuits contain 8 columns and 10 rows which form 80 cross points with a transistor at each point. When a row and column have been indicated the corresponding cross point transistor becomes conductive thereby addressing a word.

The test matrices utilize 72 test words and 2 check words of the 80 words possible. A test word contains 16 data bits (test points) and one check bit. The test point consists of inter alia a capacitor and has a time constant of 125 ms in *LT* and 0.5 ms in *RT*. During the indication of the test point a negative pulse is obtained over the capacitor. If simultaneously herewith either calling potential or zero potential is received from a relay contact in the telephony unit the bit amplifier is actuated thus permitting a signal to be transfered to the data processing unit.

Operating Matrices

The *SMR*-matrices each contain 256 operating points which are arranged in 16 words with 16 points in each word. A matrix consists of address circuits, operating points and check circuits. There are 16 address circuits, which each address one word. The operating point consists of a bi-stable transistor flip-flop which controls a reed relay. Over the contacts of the reed relay 48 V is connected for the operation of the particular relay in the telephony unit, which is to be operated. Fig. 11 shows printed circuit cards in an *SMR*-rack.

During the operation of an *SMR*-word all the flip-flops belonging to that word are first reset and after 0.8 μs those flip-flops, which in accordance with the *SMR*-data word are to be set are activated. The operation is carried out one word at a time.

Relay operation

RMR is operated over 12 *SMR*-points and supervised over 16 *RT*-points. Two *RMR* together with a connecting relay set in the telephony unit form an *RMR*-group which can operate a total of $20 \times 16 = 320$ relays in the telephony unit, divided over 1, 2 or 4 relay set racks. A doubling up of *RMR* has been carried out in order to increase the operational reliability of the system. Relays which are operated over *RMR* have their own holding contact and therefore the *RMR* only requires to be occupied momentarily. The release operation is affected by connecting + 60 V on the operating wire of the pertinent relay, the release of which is thus a result of the reversal of the magnetizing current.

The operating information from *SMR* is decoded in such a way that first a relay group of 20 relays and thereafter one relay out of 16 within that group is indicated. Thereafter a check is carried out over *RT* in order to ascertain that the indication corresponds to the order from the data processing unit, after which the indicated relay is operated.

Operation of Switches

VMR is operated over 20 SMR-points and is supervised over 20 *RT*-points. Two *VMR* form together with a connecting relay set in the switch rack, a *VMR*-group, which can operate a maximum of 32 code switches. A doubling up has been carried out amongst other things because of operational reliability reasons. If the traffic so requires a switch group can be augmented by a further one or two *VMR*. As the code switch has mechanical latching the *VMR* unit is only occupied during the actual setting operation.

Operating information from *SMR* is decoded so that one switch out of 32 and the required number of code magnets in the actual switch are indicated. Thereafter a check is carried out over *RT* in order to ascertain whether the indication corresponds to the order from the data processing unit. Finally, the code switch vertical is operated.

The Data Processing Unit DE

Survey

In the AKE-system the control functions have been centralized to a data processing system consisting of two computers operating in parallel, which supervise the signalling on the subscriber and junction lines and which establish the desired setting up of calls in accordance with the number information received. The different functional units of the data processing unit are shown in fig. 10.

In order to be able to cope with all tasks concerning the control of the telephone traffic the computers must be able to:

- read in as well as store programs and exchange data in memories
- transport data within the computers
- interpret conditions in the telephony unit via the transfer unit
- operate devices in the telephony unit via the transfer unit
- process data through arithmetical and logical operations
- store results and temporary data in memories
- feed out the results via output devices

The processing of data is carried out in accordance with programs stored in the memories and from this procedure the concept of stored program control has been derived. The memories are of the ferrite core type, which allows for simple changing of the information content by electrical means. For the AKE-system this program control means that new functions and services can be inserted into the system by a simple change or addition of programs. By using different programs the identical standardized equipment can be used to cover all desired different types of exchanges.

Each computer consists of a central processing unit *CE*, a program store *PM*, a table store *TM* and a data store *DM* as well as of associated programs and data. The computers operate synchronously and treat the same data under the control of the same program and therefore, when the system is fault free they will always show the same result. Their exact congruency is supervised by a supervisory unit *KE*, which amongst other things compares the flow of data on the internal buses of the computers and in case of disparity starts suitable malfunction routines. The supervisory unit decides then, with the aid of a test program, which part that is faulty and which combination of central processing units and stores is to remain in service. All combinations are possible and this results in maximum operational reliability. The computers cooperate with the input and output devices i.e. two electric type writers, one tape reader and one tape punch, to enable communication between the personnel and the telephone exchange. Together with the electronic interface circuitry they are included in the input and output unit *IO*. Fig. 12 shows the electronics rack of the data processing unit together with the operator desk with the in- and output devices.

The automatic supervision of both computers and data processing is carried out by the supervisory unit in conjunction with supervisory programs. A complementory maintenance equipment *TU* is provided, with the aid of which the personnel can make manual reconfigurations, execute tests and other investigations in case of interruptions in the exchange operation. Test, fault location and reconfiguration are, however, normally performed automatically.

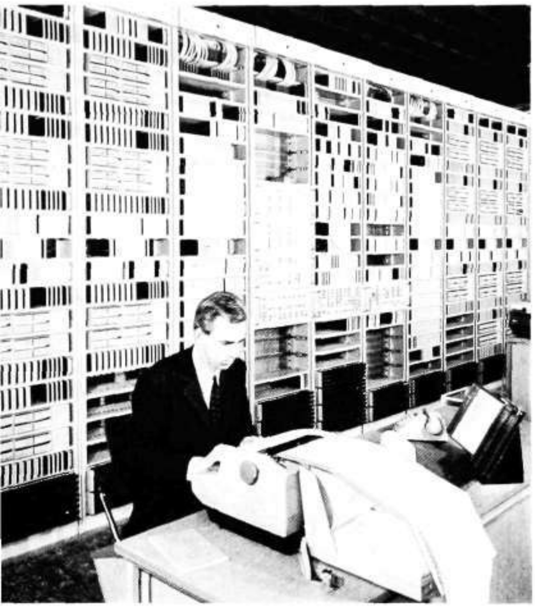


Fig. 12
Data Processing Units and Exchange Staff Desk with In- and Output Devices

The circuits in the data unit consist of very reliable electronic components. Only silicon transistors and diodes are utilized and this applies to the entire AKE-system. The logic functions are mainly accomplished by means of diode transistor logic (*DTL* of the *NAND*-type).

In the following the properties of the specially designed computer are described first, and thereafter the programs and data are treated under the heading "Programming Software". Under the heading "Hardware" the physical equipment of the entire data processing unit is described.

The Computer Properties

The computer organization and build up have been adapted for the controlling of telephone traffic, which amongst other things has influenced the structure of the instruction list which has 84 different instructions. These may be combined in different sequences by the program designers so as to obtain different programs.

Clock Interrupt Facilities

The computer must operate fast and timewise devide its tasks in such an effective manner that it will attain maximum traffic handling capacity and operate fast enough to serve thousands of subscribers. In order to ensure that no information is lost, (for example, digital information required for the setting up of connections) the treatment of data must be carried out on a real time basis. The computer has therefore been equipped with clock interrupt facilities and its different programs have been divided into different priority levels e.g. *F*, *A*, *B* and *C*. The *F*-level contains the fault diagnosis programs, which are actuated after a so called fault interrupt signal. On the working levels *A*, *B* and *C* all traffic handling occurs. Every 10th ms a clock interrupt signal is transmitted, which compels the data processing procedure to return to the *A*-level programs. The time between two interrupt signals is called the primary interval. Fig. 13 shows how the programs can be handled during some primary intervals. During each primary interval normally *A*, *B* and *C*-level programs should be handled. When an interrupt signal is accepted by the central processing unit the program in progress is interrupted and a change-over is made to data processing on the *A*- or the *F*-level. Herefore, program dependent data and relevant instruction addresses have to be stored in the data store and a jump must be made to a predetermined position in the program store. The information stored is retrieved automatically by changing over to a lower level and the data processing is continued from the point of interruption without complications. Programs are only interrupted in the joint between two instructions.

As an example it could be mentioned that the program for the scanning of dial impulses in the code receivers belongs to the *A*-level and is actuated every 10th ms, whilst the program for the scanning of subscriber lines belongs to the *C*-level and is worked through in such a manner that each subscriber circuit is scanned once every 320th ms approximately.

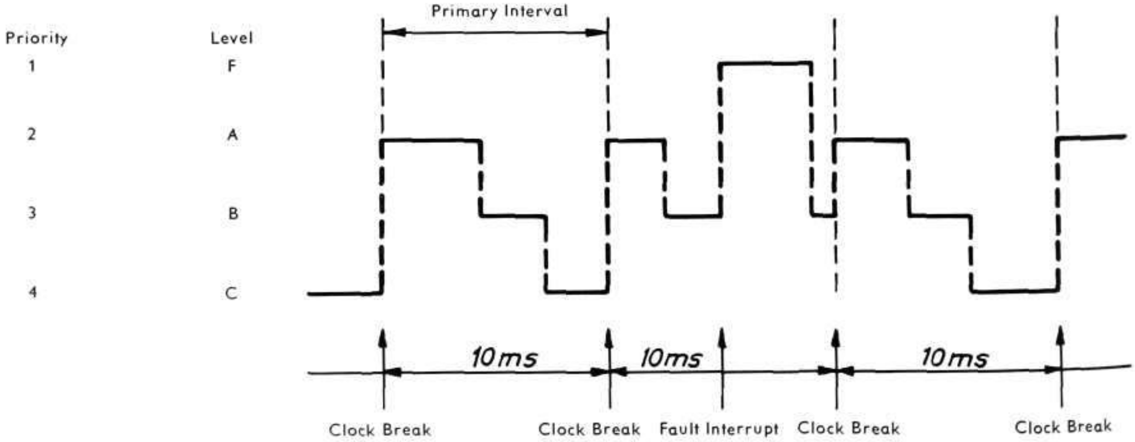


Fig. 13
Priority Levels

The Data Format

The computer is designed to operate with pure binary representation and has a word length of 16 bits. The basic underlying data format is the word which is divided into four characters with four bits in each. The stores are organized in words of 16 information bits and 2 check bits. Data processing is carried out in parallel on the pertinent amount of data to be handled, which can either be an entire word, half a word, character or one bit.

Addressing

The computer is designed for indirect addressing with double address facilities. Each of the three stores have their own address number series. Each number in the series indicates a word and is called the word address. The address is simply a number consisting of 16 binary digits. The largest address will therefore be 65335. The program and table store each contain 64k (k = 1024) words, whilst the data store only contains 48k words, as it shares an address number series with the transfer unit.

During indirect addressing the instruction contains one or two logic register addresses, which in their turn contain full 16 bit addresses. In exceptional cases a shortened direct addressing is possible for example to certain store locations with fixed start address. In such case the address only contains the address within the pertinent store location, which is done with the aid of a maximum of 8 bits. The shortened address requires special instructions, however.

Computer Instructions

The computer instructions form the medium between the hardware and the programs. Each computer instruction corresponds to a sequence of actions in the circuits of the computer (micro programs). When the central processing unit has read an instruction in the program store and interpreted this the micro program associated with the instruction is activated.

The computer operates with a fixed instruction length of 16 bits and each instruction is therefore contained within one memory word. The instruction consists of one operational part of 6 bits and one variable part of 10 bits. The operational part specifies the task to be carried out, whilst the variable part specifies which data are concerned with the operation. Each instruction can handle a determined quantity of data and separate instructions exist for word-, character- and bit operations.

The instruction list contains different types of instructions designed for example for data transfer, arithmetical and logical operations, bit- and character-operations, program jumps as well as a special feature which is called field comparison. In addition hereto, there are special checking instructions which occur in the programs which check the hardware.

F E D C B A	9 8	7 6	5 4	3 2	1 0	Bitposition
MMR	Rx	Ry	PV	A	C	

The figure above shows the disposition of the instruction word for the transport instruction *MMR*, which in plain language means *M*ove *M*emory to *R*egister. This instruction is interpreted by the computer in the following manner: "*A* character with character address in accordance with *PV* is to be transferred from the memory word, which is addressed by the logic register *Rx*, to the *A* least significant characters in the logic register *Ry*. *C* indicates if *R*y is first to be cleared or not." *Rx* and *Ry* indicate with 2 bits each, one each of the 4 available logic registers *RA–RD* in the central processing unit, which are accessible to the programmer in accordance with certain predetermined rules. The *MMR*-instruction is thus intended for indirect addressing.

The transfer of data makes up a large part of the data processing volume. For such transfers addresses are necessary, and the calculations of addresses therefore occupy a large part of the computer time. Multiplication and division are executed with shift operations. Logical operations such as OR, AND, INVERTING as well as EXCLUSIVE OR are used i.a. in order to find free devices and switching paths in the switching network. With the aid of the field comparison instructions the computer can i.a. quickly execute scanning operations and detect changes of state in the telephony unit. By means of the jump instructions the instruction sequence can be changed by jumping within and outside the pertinent program.

Programming Soft-ware

General

The computer actions are entirely determined by the programs and exchange data which are stored in the memories. The cooperation between different programs and between programs and data fields in stores and transfer unit follows certain preset rules, which are described in this chapter. The computer build up determines which instructions are available to the programmer, but apart from certain additional restrictions the software can be freely organized in accordance with a suitable programming system.

System Functions

The program system is built up of active elements or programs and passive elements or data. A program is active only during the time when it is executed. For the remainder of the time the program is directly comparable to data. In order to perform a certain system function in the AKE-system it is usually necessary to have a certain amount of cooperation between different programs and also between programs and the data fields. The system functions can be divided into the following main groups:

- *Monitor functions*, which govern and control the entire processing of data and ensure that the programs are activated at the right time and sequence, with due regard to their priority and need.
- *Traffic handling*, which comprises amongst other things signal reception, signal analysis, signal transmission, signal supervision, route selection, operation as well as supervision of connections.
- *Exchange administration*, which covers amongst other things the loading of stores when the exchange is put into service, extended or when its function is being changed, the input and output of messages as well as functions for the operation, maintenance and testing of the exchange as well as changes in subscriber facilities and traffic measurements.
- *Supervision*, such as functions for fault detection, alarm and fault localization.

Programs

Each system function is divided into one or more programs in accordance with the rules governing the program system. Three main types of programs exist i.e. monitor programs, indicating programs and operating programs. Certain parts of operating programs have been allocated a more autonomous position, and are called routines.

- *The monitor program* is run through every primary interval, for example immediately after a clock interrupt. The program contains references to different indicating programs and keeps track of whether these are to be activated or not.
- *Indicating programs* which identify those telephony devices and store fields where action is to be taken and which call the operating programs concerned.
- *Operating programs* and routines which carry out the required measures.

All indicating programs belong to one of the priority levels *A*, *B* or *C* and have been allocated suitable activation intervals. The monitor program activates the indicating programs with regard to priority and interval and in such a manner that the primary intervals are loaded approximately equally. The monitor program also governs the interoperation between different programs.

Most of the programs are stored permanently in the program store *PM* or the table store *TM*. Programs for less frequently used system functions are stored on a punched tape which the operator can feed into a free buffer area in the program store as he requires. The punched tape acts as a kind of external store to which the central processing unit has no direct access. The program for call meter reading is normally only used four times a year and can therefore be stored on a punched tape without any inconvenience arising.

Data

The data concept comprises all information on which the programs operate. Exchange data have been mentioned earlier, as the name for that type of information which is fed into the exchange store together with programs and which describes the size of the exchange, the number series, the traffic handling and the intermediate connections. In the following some different types of data are described.

- *Fixed or permanent data* indicate i.a. how the stores and transfer unit are utilized and are changed only as a result of extensions or changes in the exchange functions. They are stored in the store fields, which are protected against unwarranted changes.
- *Semi-permanent data* describe how the devices in the telephony unit are interconnected, how the subscribers and junction lines are connected, and indicate the rules governing the traffic handling and the coverage of the telephone subscription rules of subscribers. Due to the movements of subscribers and changes in the traffic it should be simple to change semi-permanent data, whilst the exchange remains in operation. This is carried out by means of commands, which the exchange personnel type out on the type writer key board.
- *Temporary data* comprise all the information, which at a certain instant describes the traffic in progress. An example of such data are the external data, which are fed in over the transfer unit and have their origin in the changes of state of the telephony unit as a result of incurred outer occurrences, over which the system has no control.

In the data store *DM* all data are stored, which are to be easily accessed by the central programs during the handling of traffic. The table store *TM* contains mainly the large amounts of semi-permanent data, which are related to subscriber numbers and junction line circuits. In order for the computer to be able to find its way in the stores data are arranged in fields with each field connected to a store address. The size of a field can be varied from one bit up to several words. Fields of the same type are addresswise arranged next to each other thereby enabling addressing by means of a basic address and a sequential number or index. For example each code receiver and each cord circuit has a corresponding store field. Fields exist which can be considered to be independent traffic carrying devices, for example fields with marker functions used during switch- and relay operations.

Data can thus belong to different system functions, be stored in different fields and have different character. The field organization is an important part of the program system. During the execution of a system function the program interworks with a field but even different fields interwork with each other. The linking together of different fields is carried out by means of direct address linkages. Within each field the data are arranged in a pattern which is compatible with the programs. By using different types of interpretation aids the exchange personnel can interpret the contents of the fields, which can give them valuable information about occupation of devices, traffic distribution and fault occurrences etc. etc. in addition to the information, which is automatically obtained from the metering cells in the data store.

Hardware

General

Each computer consists of a central processing unit *CE*, a program store *PM*, a table store *TM* and a data store *DM* and occupies four electronics racks. The Tumba data processing unit comprises a further three electronics racks for the supervisory unit *KE*, the in- and output unit *IO*, as well as the maintenance equipment *TU*. In addition hereto there is an operator's desk with in- and output devices. A block schematic of the data processing unit is shown in fig. 10.

The Central Processing Unit CE

The central processing unit is responsible for implementing all pertinent data processing and executes the tasks indicated by the program. The exchange of information with the stores, the transfer unit, the supervisory unit and the in- and output units is carried out over different buses. The central processing unit main parts are the control unit, the logic unit and the transfer buses. The latter form the internal transfer route between the many registers of the central processing unit. A register allows temporary storage of data during the actual data processing time or in connection with transfer. *CE* is mainly built up of logic circuits, the reaction time of which is approximately 0.025 μs.

The control unit SE interprets the instructions, which are incorporated in the programs and which are read out in the proper sequence from the program store to the operating register *OR*. After decoding *SE* sends signals over the control circuits to the logic unit, the stores, the supervisory unit, the in- and output devices, in other words to practically all parts of the data processing system. The control signals are timed by a crystal controlled clock oscillator with a frequency of 5 MHz. Each control signal actuates a function (micro operation). By selecting micro operations in a chronological order in a micro program network the micro program is formed for the machine instruction concerned. One micro operation is executed in 0.2 μs. In the control unit the clock interrupt signal which returns the data processing function to the *A*-level every 10th ms is also generated.

The logic unit contains an arithmetic unit *LA*, which can execute logical and arithmetical operations, as well as a number of registers in which the information can be stored during the data processing. Some of the registers are available to the programmer for program design, whilst the others function as buffer registers. Amongst the former are four logic registers *RA*, *RB*, *RC* and *RD*, which are used for indirect addressing and for the storing of partial results, to be used later on in a program in progress.

The arithmetic unit contains adding circuits, which execute logical or arithmetical addition of the operands in the registers *AR* and *HR*, as well as write the result in register *RR*. In the indicator flip-flop *SEF* the overflow of arithmetical operations and results, differing from zero in logical operations are indicated. An addition of two entire words is executed in 0.6 μs.

Stores PM, DM and TM

The program store *PM*, the data store *DM* and the table store *TM* are built up of identical memory modules. *PM* and *TM* comprise a maximum of four modules, whilst *DM* consists only of three modules. One module contains four memory stacks, each containing 4096 words. *PM* is designed for the storing of programs, whilst *TM* is used for storing both programs and data. *DM* finally contains only data.

The storage elements are ferrite cores, which are arranged in memory matrices and operate in accordance with the principles for coincident selection. The ferrite core can be magnetized in either one of two directions and is therefore suitable for the storage of binary information. Each core is run through by 4-wires, two of which are used for addressing, one for the output signal when the store is read and one to separate between zero and one when writing into the store. This type of store is destructive, which means that the information is erased during the reading-out operation. After each read-out the result is used for a renewed read-in. The time for read-out and read-in, i.e. the cycle time, is 6 μs. The speed of the computer is mainly determined by the cycle time of its stores. Most of the instructions are carried out in 6 μs, whilst a few need 12 μs. Information read out is available already after 1.8 μs and the processing speed has been further increased since it is possible to read an instruction whilst the previous instruction is still being carried out. Between the central processing unit and stores there are buses, which are connected to the register unit of each store. During read-out and read-in an address is transfered to the address register of the stores *PA*, *DA* or *TA*. An order to read triggers driver signals from the logic unit of the store resulting in the information stored at the address indicated being transferred to the result register of the stores *PR*, *DR* or *TR* for onward transmission to the transfer register *TR* in the central processing unit. Writing orders result in the information, which has been received from the central processing unit in for example the *DR* unit, being written into the address indicated.

All stores contain a large amount of information, which is to remain unchanged as long as the exchange functions are not changed. Therefore store protection has been introduced in order to prevent writing into those storage areas, which store programs and other fixed data. Also call meter stores are protected. A faulty program or a faulty operation by the exchange personnel cannot therefore cause important information to be destroyed. The store protection can be canceled for the authorized writing into the protected areas.

The Supervisory Unit KE

The supervisory unit is connected amongst other things to the buses of both the central processing units between these and the stores and continuously compare the flow of data. Alarm circuits from different parts of the data processing system are also connected to the supervisory unit. When disparity occurs or some other alarm is initiated *KE* decides on suitable measures and orders these by means of signals over the control wires to the central processing units. The measure taken can consist of a fault localizing program being activated or of a certain configuration of central processing units and stores being selected for continuous operation. During the normal condition of the data processing unit all exits from *KE* are blocked and are opened during alarm condition only provided the *KE* is free of faults. *KE* is checked every 20th minute by a routine test program. *KE* also contains an indication and operating panel in which the different units either in operation or faulty are indicated. By means of control buttons the operator can amongst other things change the configuration of units or demand separation of the computers.

In- and output Unit IO

The computers communicate with the exchange personnel over two type writers, one tape reader and one tape punch. In addition hereto indicators are provided for optical or acoustical alarm.

The type writers SK are utilized by the operator for changing exchange data or for the start of traffic measurements etc. Some 100 commands are specified for all the measures which pertain to the operating of a telephone exchange. A command consists of an order part of type SUBSCRIPTION CHANGE in plain language and a variable part in which in this case for example the subscriber number is indicated. The type writers also automatically type out outputs from the system. These can consist of check printouts as a result of a command, traffic measuring results, alarm information, occupation condition, blocking condition etc. Each type writer is associated with alarm indicators and a category lock. By means of a key the operator indicates that he is authorized to execute commands pertaining to a specific category.

Tape reader RL is used for the feeding in of large quantities of information, for example during the initial loading of programs and exchange data in connection with putting the exchange into service.

Tape punch RS is used for large outputs and when an information is desired in a form which is directly suitable for subsequent treatment in an administrative computer. The call charging details for example consist of a punched tape, which contains the subscribers' meters positions of all the subscribers.

Interface electronics between each in- and output device and the computers is provided in the *IO* rack. The in- and output devices normally communicate with the computer which is executive, but the operator can by means of an operating panel, for example be connected the non-executive computer. From this panel the initial read-in of programs is also started and this must occur under the control of the read-in unit in cooperation with the tape reader until the read-in program has been loaded into its proper position in the program store, thereafter controlling subsequent program read-ins.

Maintenance Equipment TU

TU is designed to be utilized when testing and fault locating in the hardware and software is carried out manually and constitutes a complement to the automatic fault locating facilities. Normally, the equipment is automatically connected to the central processing unit of the particular computer, which has been marked as faulty at the order of the supervisory unit *KE*.

TU consists mainly of four operating panels containing indicators and push buttons. Every bit in the logic register *RA–RD* is, for example, equipped with an indicator and the push buttons enable the instructionwise or positionwise stepping of the program.

Control Console

In Tumba the processor room is used also as the control room. The exchange personnel dispose over two attendance positions consisting of a desk equipped with type writer. The type writers are complete with a contactor unit for the power supply and a paper feed unit for the storing and collecting of typing paper. The paper feed unit is equipped with an alarm contact, which operates when the paper nears its end. One desk is equipped with an alarm and control apparatus, which amongst other things enables detailed alarm indication to be obtained. From this position the operator can follow the traffic either by controlled or random connection of monitoring equipment onto a connection while being set up.

A third table provides space for the tape reader and tape punch. The processor room also contains space for storing spare material, tape rolls with programs and exchange data as well as exchange documents.

Switching Sequences

General

In a stored program controlled system the traditional exchange functions are carried out through cooperation between programs in the data processing unit and switching devices in the telephony unit. The functions are described in functional flow diagrams, in which a method of drawing using such symbols as triangles, squares and rings has been utilized. A switching sequence is controlled by one or more programs, which are roughly described in general descriptions and more detailed in program descriptions containing so called source programs. The latter contain the information, which the programmer writes down when coding the programs. The source program studies require that the reader has a complete knowledge of the computer instructions and the rules for programming.

The following table shows in which order some essential programs process the data which concern a local connection as well as an example of the activation interval and priority levels.

The table shows the activities sequentially executed by the program starting from a certain switching sequence. The computer, however, does not operate only with one switching sequence at a time, as for example occurs in the marker of a relay system, but operates with functions one at a time, which can involve all switching sequences or all subscribers.

As a complement to the above table the following describes the setting up of a local connection in general wording. The description has been made starting out from the functional flow plans and indicates how the functions have been divided between the different programs and how these cooperate. The program titles are indicated within brackets, for example (ALT).

Table of local connection processing sequence.

Function	See fig. 14	Program ms	Interval	Priority level
CONNECTION OF CODE RECEIVER				
Subscriber circuit scanning	*a*	ALT	320	C
Administration of route selection		BMR		
Selection of switching path to free KM		MK1		
VMR-data calculation for operation of switches		MOA, MOB M1A, M1B		
Occupation of VMR-queue		MV1		
Switch and relay operations	*b*	MMI a. o.	10	B
Operation of SLVA		MK2		
Time measurement 180 ms		MK3		
Switching supervision		MAV		
CODE RECEIVER STATE				
Transmission of dialling tone from KM	*c*	MK4		
Digit reception in KM	*d*	KLT	10	A
Registration of digits and end of selection signals		KLE	80	B
Number analysis		REI a. o.	10	C
Category analysis		REI a. o.	10	C
THROUGH UP CONNECTION TO CALLED SUBSCRIBER				
Administration of route selection		BMR		
Selection of switching path		MS1		
Release analysis of KM connection		MAI a. o.	10	C
Release of KM		MC1 a. o.		
Switch operations, setting up and release	*e, f*	MMI	10	B
Transmission of ringing signal and ringing tone		MS6		
CONVERSATION STATE				
Link circuit scanning	*g*	SLT	40	B
Registration of disconnect signals		SLI	80	B
Subscriber meter stepping		FZ3		
Release analysis		MAI a. o.	10	C
Switch and relay operations		MMI a. o.	10	B
Subscribers marked free		MC7		
		ALT	320	C

Connection of Code Receiver

When a subscriber lifts his handset the potential in his *LT*-point changes, which is detected by the line scanning program (ALT). By means of field comparison successively one 16 group of subscribers after the other is addressed and the line states of the 16 pertinent lines are transferred to *FR*. The computer compares the binary number in *FR* with the content in the data store word, which contains the result of the previous scanning operation. Disparity in any bit position means that the computer has to take action and (ALT) calculates the address to the field, which concerns the subscriber in question. Thereafter the information is analysed in the subscriber field in order to determine whether for example a call or a replacement of handset has occurred. A call causes (BMR) to be activated, which coordinates the selection of route and the setting up of the switching path. (*MK1*) selects a free code receiver *KM* and switching path to the subscriber. If the selection is successful the occupation bit in the data store pertaining to the verticals concerned is marked busy. (*MK1*) thereafter activates the routines which calculate the *VMR* data for the following switch operations and reads-in these *VMR* data into the *MA* field, which is a field having marker functions. The subscriber is marked busy by (*ALT*), which also investigates whether any special category applies. At this point (*ALT*) continues with the field comparison in order to investigate any possible changes of state in other lines. Independently of (*ALT*) the monitor program calls (*MMI*) at a later point, which effectuates all requisite operations in accordance with the applicable queuing sequence. During relay and switch operations the computer writes a binary number into *FR*. Thereafter the information is transferred to the *SMR*-word, which is addressed by a binary number in *FA*. The bi-stable flip-flops in *SMR* control the signal transmitting relays or the operating equipment *RMR* and *VMR*. In the case described one of the two *VMR*:s, which are associated with each of *GVLA*, *GVLB*, *SLVB* and *SLVA* switch, receive operating orders and the switching stages are set up. (*MK3*) assisted by (*MAV*) executes a time measurement and after 180 ms all settings have been completed. The subscriber has then been connected to a code receiver.

Code Receiver State

After the setting up (*MK4*) starts three sequences, i.e. the transmission of dialling tone, the scanning of dialling pulses for the reception of digits and the supervision for a possible on hook signal from the subscriber. At the same time those store fields, which were engaged in the setting up of the call are freed. Dialling tone is sent out after the connecting relay and the tone relay in *KM* have been operated. The subscriber obtains current feed through the impulse relay in *KM*. The digit reception is carried out by (*KLT*), which is an A-level program with an activation interval of 10 ms. It scans the impulse contact in each occupied *KM* and has to be fast enough to count every dialling impulse which can be generated at rates up to 22 pulses per second. When the first impulse is received the dialling tone is cut off. (*KLE*) is activated with an interval of 80 ms and investigates whether a possible on hook signal exists. (*KLE*) also starts a time supervision of *KM* of 75–90 s, which is prolonged by 45 s, when the first digit has been received. (*KLT*) and (*KLE*) see to it that one pulse after the other and one digit after the other is registered in the particular data store field which is allocated to *KM*. The number analysis program (*REI*) is activated and analyses this digit information in all code receiver fields. Route selection can be performed as soon as a sufficient number of digits has been received.

When the entire number has been received the state bits for the called subscriber are scrutinized. If the subscriber is free a category analysis follows in order to determine whether or not any restrictions apply to the incoming traffic.

Through Connection to Called Subscriber

It is presumed in this case that the called subscriber is a normal subscriber without any special category. The selection of the switching path between the subscribers is carried out on the basis of the data pertaining to the state of occupancy of the switching stages and switching devices contained in the store. (*BMR*) again governs the proper coordination between the route selection and the setting up of the connection. The switching path is marked as busy, the *VMR*-data are calculated and finally, the setting of switches is initiated. When data for the final connecting through have been obtained, the switches in the code receiver stage are ordered to release. The release sequence starts with a release analysis. The release of *KM* can occur approximately simultaneously with the final connecting-through operation. The restoring of switches takes approximately 140 ms. In addition to switches relays in the

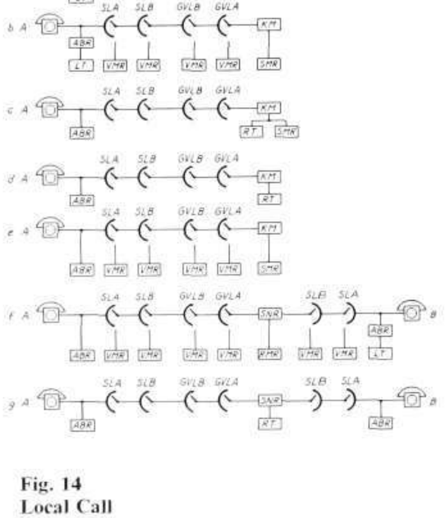


Fig. 14
Local Call

SLA, SLB	Subscriber Stage
GVLA GVLB	Local Group Selector Stage
KM	Code Receiver
SNR	Link Circuit
ABR	Subscriber Line Circuit
LT	Line Test Unit
RT	Relay Test Unit
SMR	Buffer Store
VMR	Switch Operating Unit
RMR	Relay Operating Unit

SNR-L are to be operated in order that the A-subscriber receive current feed and ringing tone, and that the B-subscriber receive ringing signal. In the store field, which belongs to *SNR-L*, data are read-in which define the switching path between the two subscribers.

Conversation State

When the switch-through has been completed, the connection is supervised over *SNR-L* by the link circuit programs (*SLT*) and (*SLI*). The current feed relay of each of the subscribers in *SNR-L* has a test contact, which is scanned by (*SLT*) every 40th ms. When the called subscriber answers, the subscribers are connected together by the ring trip relay. This function is performed by relay logic and is therefore an example of a function, which has not been programmed. (*SLT*) notes the signal and changes the data in the link circuit field after which the subscribers are marked as being through connected. During the conversation, the scanning by (*SLT*) is repeated every 40th ms in order to note a possible on hook signal. When (*SLT*) in fact discovers this occurrence for any subscriber a time measurement is started, which leads to release after 3–6 minutes. During a normal conversation both subscribers replace their hand sets approximately simultaneously and the release is started as soon as both ring-off signals have been registered by the computer.

The contents of the calling subscriber meter word in the data store are increased by one. Thereafter a release analysis is carried out, which results in the generation of *VMR*-data. When every switching stage has been released, all busy devices and associated store fields are released, and both subscribers are indicated as being free.

Service Supervision

Centralized Supervision

High operational reliability has been attained in the central data processing system by the selection of components with high quality, and by derating to obtain safe operating margins when dimensioning circuits. Examples hereof are the duplication of functional units in the data processing unit and transfer units, as well as the introduction of special circuits and programs, which continuously supervise the data processing and automatically take action on fault indication.

The centralization of the control functions enables effective supervision of traffic, of the traffic carrying devices and of the subscriber and junction line circuits, which are connected to the exchange. The traffic handling programs immediately detect imperfections in the devices as well as the lack of devices or faulty devices. In addition hereto there are special programs for the supervision of traffic, which give service alarms when the number of congestions or blockings exceeds a preset limit. The alarms are indicated on alarm panels in the exchange itself and are also transferred over superfantom connections to the maintenance centre in Stockholm. Four classes of alarms with varying degrees of urgency exist.

Service Routines

The service personnel communicates with the exchange by means of the earlier described input and output devices. The type writers constitute the most important means in this connection. By means of a written command the personnel can execute changes in subscriptions, demand traffic measurements, start tests of different kinds, block devices and execute other actions which are typical for the running of a telephone exchange.

Information from the telephone exchange is automatically written out in plain language or in coded form. As a complement to alarm indications alarm messages are also obtained, which in many cases directly indicate the necessary measures to be taken by the personnel. This may concern the specification of the faulty device in the telephony unit or of a faulty printed circuit card which is to be changed. At the request of the personnel the contents of the data store traffic and blockage counting words are typed out as well as the state of occupation and blockage within indicated groups of devices or routes.

The principle working area for the personnel is the combined processor and control room. With the aid of the processor input and output devices the station supervisor or operator obtains information about the condition of the exchange and can order the necessary measures to be taken. All manual action in the telephony unit has to be based on information obtained from the processor as indicators and jacks do not exist in the telephony devices as a result of their simplification. The work on main distribution frames and intermediate distribution frames has to be carried out as in conventional telephone exchanges but to a considerably reduced extent. The changing of numbers can be carried out without having to shift the main distribution jumper wires as a result of the free allocation of catalogue numbers in the subscriber multiple. The intermediate distribution frame work is also reduced as only the speech wires have to be jumpered. Every action in the main distribution frame and intermediate distribution frame has to be followed by a command to update the information contained in the data store.

Supervision of the Data Processing Unit

In order to obtain the outstanding operational reliability the data processing unit contains two computers operating in parallel.

Normally both central processing units operate synchronously and treat the same data. The data flow on the buses is continuously supervised by comparing circuits, which indicate mismatch alarm to *KE* as soon as a disparity occurs. In addition hereto, there are circuits for the parity control of the stores, as well as check bits in the transfer unit and supervision of voltage and clock pulses. By correlating circuits and programs a check is made to see that the computer actually runs through all its tasks. If this is not the case the program execution alarm routines *PAL* are initiated. *PAL* results in the computer automatically taking the necessary action in order to be able to continue data processing from a clearly defined starting point. When comparing circuit alarm occurs *KE* orders both computers to resort to a test program, which during approximately 10 ms tries to determine which computer is the faulty one. This coarse test does not always lead to the desired result, partly due to the fact that intermittent faults can occur, partly because of the fault possibly having a less serious character. In this case *KE* allows one computer to serve the entire exchange, whilst the other computer is stopped for a more accurate check. A test program tries now to start *CE*, *PM*, *TM* and *DM* one at a time and each faultless unit is returned to synchronous working together with the still operating computer. If this restarting procedure is completely successful the fault is considered to have been intermittent and the system thus again becomes completely duplicated. If a fault alarm occurs during restarting it is straight away assumed that the last connected unit was faulty. It is therefore indicated as being faulty, alarm is transmitted and a message is typed out on the type writer for the personnel to act upon. The faulty unit is now automatically submitted to a series of tests in order to localize the fault. The test result is written out in a code, which the exchange personnel can decipher with the aid of a cross reference table which is included in the operating manual.

When alarm occurs *KE* thus automatically initiates these procedures in order to ascertain that only fault free units continue the operation of the exchange. Faulty units are blocked and the exchange operation is continued with partial duplication of the computer equipment until the personnel has taken action.

Repairs can normally be carried out by changing printed circuit cards. By means of control buttons in the operating panel the computer is ordered to reconnect and check the repaired unit.

Remote controlled from a test panel in the *TU*-rack, a computer can be taken out of service and connected to indicators in that rack. The data processing procedures can then be followed in accordance with special test programs either at normal speed or by means of a manual stepping of the instruction sequence. The starting and stopping of the computer in arbitrary program and time positions is possible which is an excellent aid during the localizing of marginal or data dependent faults. The possibility also exists to vary, from the test panel, the rack voltages, which is something which effectively indicates marginal faults. A check of the general condition of computers is suitably carried out in connection with repairs by means of marginal voltage tests.

Supervision of the Telephony Unit

Supervision of Real Traffic

The computer is always completely informed as to the traffic both with regard to established speech paths and connections being set up. In computer controlled telephone exchanges it is therefore natural to study the real traffic and from this to collect those statistics which are required for the determination of the service quality. The traffic handling programs step counters in the form of data store words and the programs have outlets for the metering of calls, occupations, congestions and faults.

The faults are summed up or accurately specified in immediate print outs. The service personnel therefore dispose over very complete data for fault correction.

Test Traffic

For checking the actual speech path it is necessary to generate test traffic. During this procedure faults on the speech wires, current feed relays, impulse relays and ring trip relays can be detected. The test traffic is generated in accordance with the principles for the conventional traffic route tester.

Subscriber Line Measurement

In order to check the subscriber lines in connection with fault reports an automatic measuring device exists, which permits complete measurement of the transmission properties of the subscriber line. The device is designed on the principle for phase angle measurements and the result is interpreted by the computer. The measurements are carried out with or without the subscriber's assistance and are started by a command to the computer. The possibility exists also to carry out a check of the dial. The measuring device is used also for the programmed testing of all subscriber lines during periods of low traffic.

Relay Interlocking Plant of the Danish State Railways

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The Danish State Railways, in cooperation with Dansk Signal Industri A/S, have designed a new type of relay interlocking plant–called DSB 1964. The system is based on the geographical circuitry principle and was designed primarily for Copenhagen Main Station. System DSB 1964 is described in this article with particular reference to the plant at Copenhagen Main Station.

Reference was made in Ericsson Review No. 3, 1954, to the decision of the Danish State Railways to abandon the *electromechanical* interlocking plants used up to that time and to adopt relay interlockings instead. Special reference was made to the plant at Odense, which was commissioned in May 1954.

Since that time a number of stations have been equipped with the new type of plant, while at larger stations a relay set for shunting routes has been introduced, i.e. a relay set containing the necessary relay equipment for control of a dwarf signal, establishment of the associated shunting routes and automatic release of the routes.

The Danish State Railways' largest relay interlocking plant of this kind is at Nyborg, and it comprises, among other equipment, 148 centrally controlled points, 7 platform tracks, 14 ferry tracks and 6 goods tracks. The plant was commissioned in 1963.

The preliminary investigation of this plant, however, showed that a very large amount of administrative work would nevertheless be required in order to establish the traffic specifications for the plant, since most of its functions related to very complicated shunting movements at the ferry berths.

When it was therefore decided in 1962 that Copenhagen Main Station, Main Line Section, should have a new plant (see fig. 1) in replacement of that installed in 1911 with 6 signal boxes and some 130 centrally controlled points, a technical–and to some extent also economic–cooperation was initiated between representatives of Dansk Signal Industri A/S (DSI) and the Danish

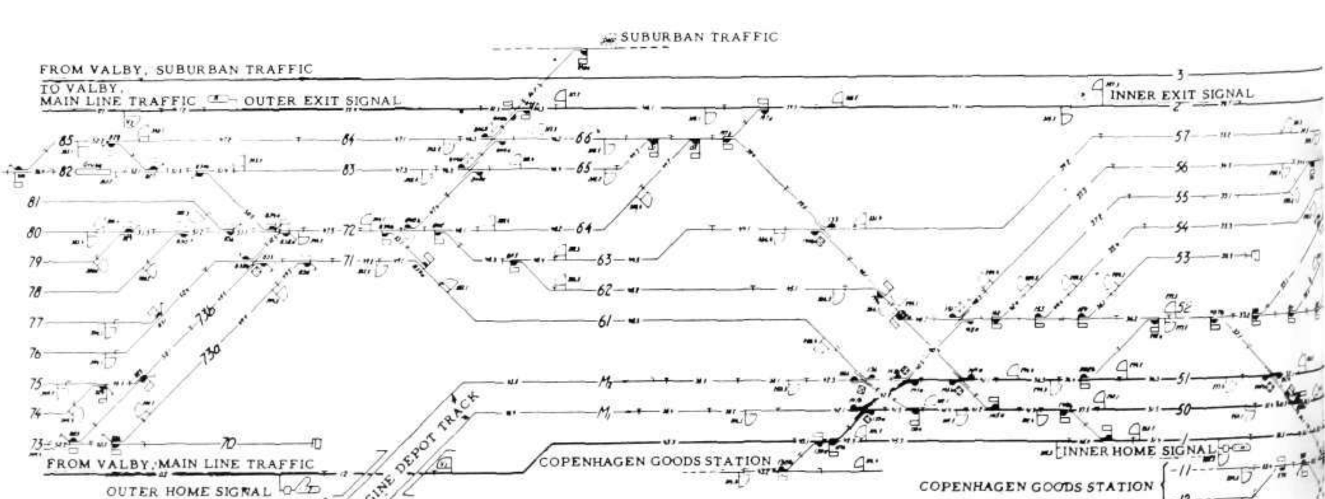


Fig. 1
Schematic track diagram and signalling diagram for the new interlocking plant at Copenhagen Main Station.

Fig. 2
Schematic survey of signal concepts which can be displayed from dwarf and platform exit signals.

State Railways (DSB) with the aim of creating an entirely new type of plant, the three chief objects of which would be:

that the plant could be operated without use of the many operational instructions with associated plans required for earlier types of plant,

that the extent of administrative and qualified design work should be considerably reduced,

that the supervision of the safety functions should as far as possible be automatic.

Before going on to the properties of the new plant it should be mentioned that DSB use a combination of shunting and main signal called platform exit signal (fig. 2). This consists of a dwarf signal and an exit signal for a main line track.

The technical cooperation between DSB and DSI, which started in January 1963, was essentially completed by 1964, for which reason the new type of plant is called DSB 1964. But even if the design principles had then been established, the new type of plant contains so many technical components which had to be designed and tested in production that the plant for Copenhagen Main Station could not be commissioned until 1967.

Characteristic Design Features

The new type of interlocking plant is built up in principle of 17 standard elements (relay sets), each type of relay set being *programmed* to execute a specific traffic function, the extent of which is determined on the basis of what may occur in a large yard with intense traffic.

The individual relay sets are interconnected by cables (*track cables*) in the same way as track sections constitute a connection between points and signals and between sets of points.

The new type of plant has the advantage that a large part of the equipment can be ordered as soon as the first track and signal diagram exists.

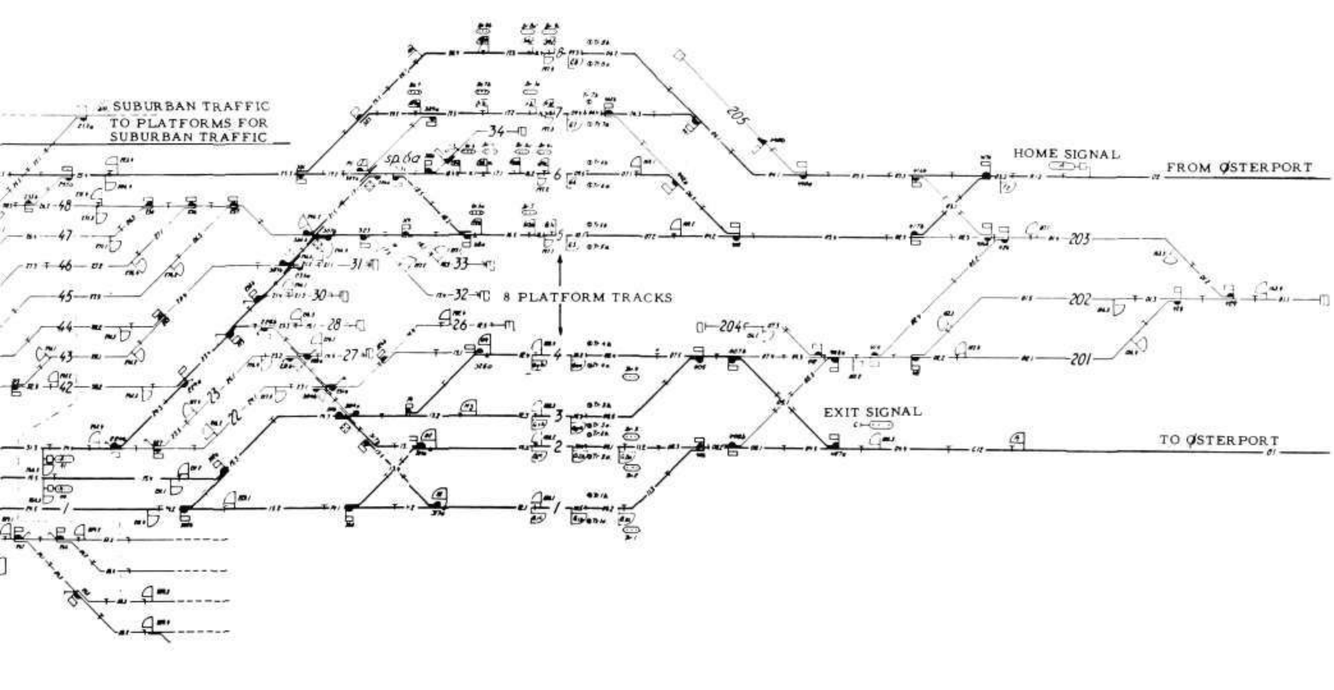


Fig. 3 shows an example of how a given track and signal diagram is converted into a diagram providing information concerning the types of relay sets to be used and how they are interconnected by track cables.

Fig. 4 shows the function of the seven most used relay sets and the rack cables leading to them.

Fig. 5 shows how relay sets for switching of points etc. are linked up with the remainder of the plant.

As will be seen in fig. 6, the relay sets are placed on double-sided racks. The connections between the relay sets are established by means of flexible PVC cables, 40 × 0.7 mm.

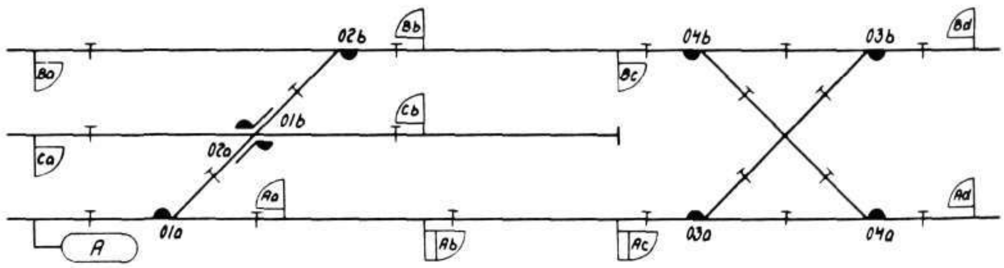
The relay contacts are *not accessible* to the maintenance personnel, but can be observed through a transparent plexiglas window. The relay sets are supplied sealed by DSI and with a test certificate for each relay set (see below). Three test terminals are inserted in the plexiglas.

All cables to a relay set are rendered accessible for testing by pulling out the relay set as shown in fig. 7.

Use is made throughout of DSI's miniature safety relay (fig. 8), which is made in accordance with ORE's 1962 specifications for safety relays with silver contacts. The relay has 10 gold-plated contacts. The magnetic circuit of the relay is made either of ordinary magnetic iron or of steel, in the latter case for applications requiring magnetic holding of contacts which are closed in the operated position.

Fig. 3
Example of the conversion of a track and signal diagram into a relay set connection diagram with associated track cables.

SCHEMATIC TRACK AND SIGNAL DIAGRAM



RELAY SET CONNECTION DIAGRAM

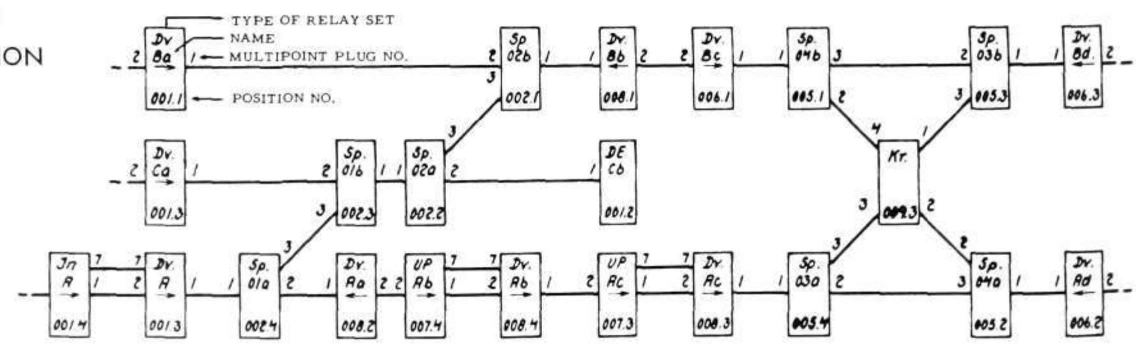
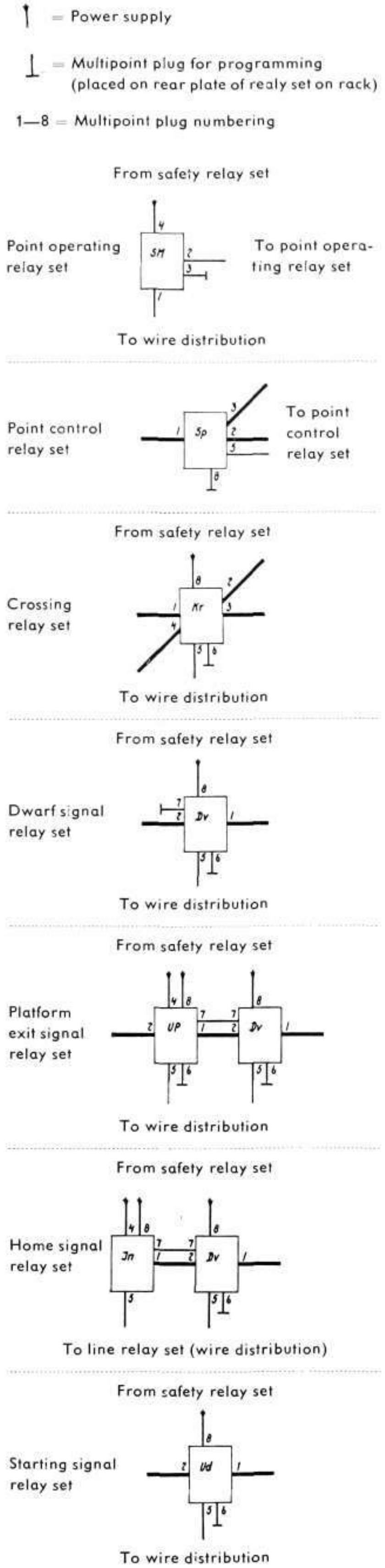


Fig. 4
Function of the 7 most used of the altogether 17 relay sets in the new type of plant. Thick lines mark track cables. Each type of relay set has code pins which fit into corresponding holes in the sealed rear plate which is fixed to the rack and contains the multipoint plug connections.



By performing fully automatic tests of relay sets, track cables and the like, DSI can guarantee to DSB that the products are free from fault.

The tests are divided into functional and safety tests.

The object of the *functional test* is to decide whether all relay and contact functions exist. The relay timing conditions and the like are also checked. The test is made at three voltages, maximum, normal and minimum. The entire series of tests takes two minutes for the largest relay set.

The object of the *safety test* is to reveal whether the wiring is correct between the individual relay contacts and between them and the soldering tags of the multipoint plugs. The test reveals both too many, too few, and wrong wiring connections. The entire test comprises about 658,000 individual tests and takes about 30 minutes.

The control panel (fig. 9) is built up on a mechanically stable iron rack covered with a species of wood which fits in with the other furniture in the control room.

The basic elements are DSI's panel components described in Ericsson Review No. 1, 1960.

The control panel for Copenhagen Main Station, which measures 330 × 68 cm², contains:

582 push-buttons

406 lamp-holders for one lamp each

954 lamp-holders for two lamps each

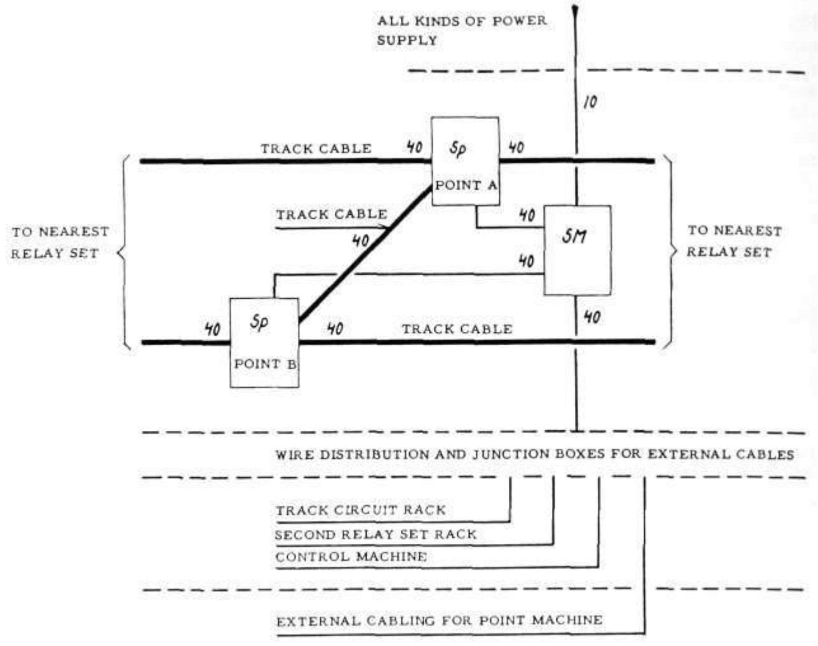
At the top of the control machine there is a special panel for a train annunciator system which advises by means of two code lamps which trains and maintenance cars are approaching Copenhagen Main Station and which are about to depart from the platforms.

Characteristic Operational Features

Centrally controlled points. Since the establishment of the first electrical interlocking plant (around the turn of the century) DSB has used "coupled" points, i.e. both ends of a crossover are operated from the same lever.

This principle has led not only to satisfactory economy through the saving of space in the control machines and cheaper cabling, but is also has advantages from the safety aspect through the easily attainable "compulsory" flank protection of the train route. In the new type of plant the actual switching and control of "coupled" points is effected by a common control relay set, so preserving the advantage of flank protection as well as the not inconsiderable saving of cabling. For the automatic control one relay set is required per point.

Fig. 5
Relay sets and rack cabling associated with a pair of coupled points in a crossover. Thick lines mark the track cable. Sp is the point operation relay set, SM the point control relay set.



Each point can be *latched manually*, which is used for example for shunting movements. The manual latching is cancelled automatically on a regular train or shunting movement.

Each point can also be *locked* in any desired position, so that a route can be established only in that position; this form of locking is used, among other purposes, for preventing entry onto a track on which work is being done, and the locking can be both established and cancelled *manually*.

If the track is arranged so that shunting between two points can be done on several routes, particular points can be given preference.

On depression of the *start button* for the signal from which the shunting movement is to *start*, the control machine itself shows which routes are available.

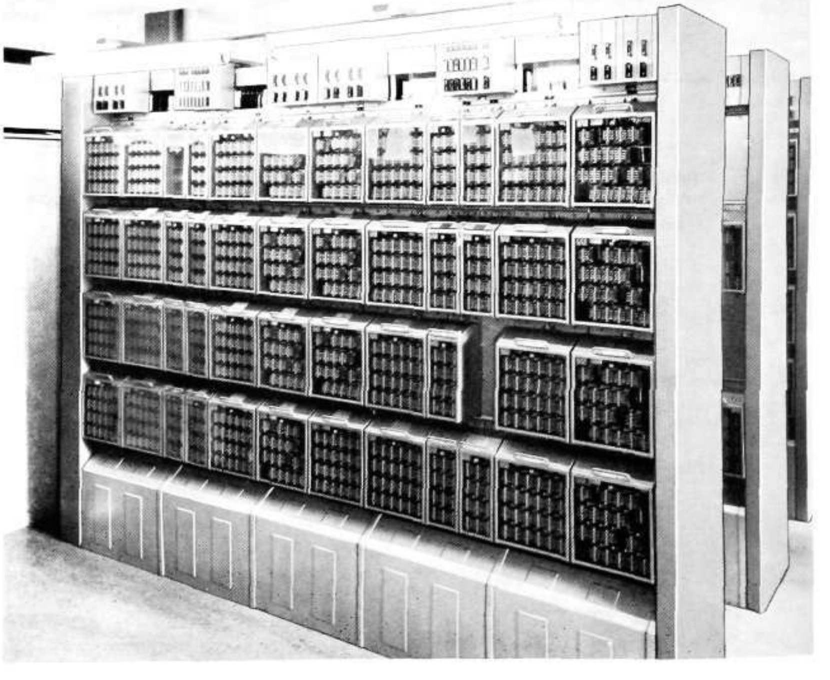


Fig. 6
Racks at Copenhagen Central Station with relay sets mounted on both sides.

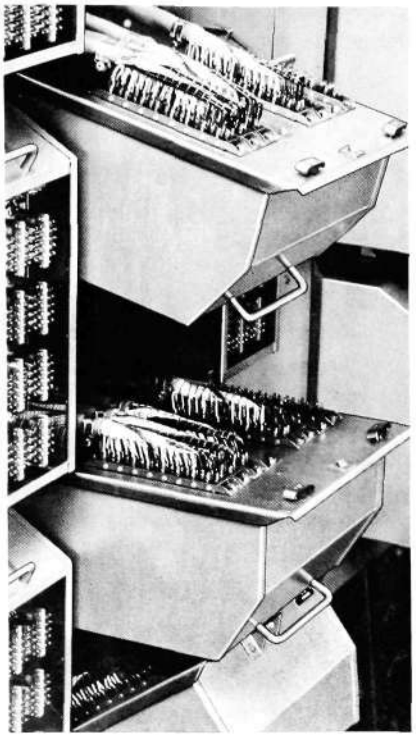


Fig. 7
The photograph shows how the cabling to a relay set can be made accessible for tests by tilting the relay set forwards.

The end points of the main routes accessible to a start button are shown by yellow flashing light on the track diagram; and if the button is pressed at the end point for the shunting movement, all other shunting routes are immediately excluded.

Provided that there is no danger in establishing the desired shunting route, including the situation of the track concerned is free, the following events automatically take place:

Switching of the points to be traversed and which are not already correctly positioned.

Establishment of the route.

Locking of protective points in protective position and of protective signals in "No entry" position.

When these functions have been completed, all dwarf signals to be passed by the cut are switched to "Proceed".

If the conditions for "Proceed" are not completely fulfilled, the dwarf signal remains on "No entry". If the operating personnel thereafter–for example through the use of shunting radio–make sure that there is no risk in setting "Caution" for the cut, the control button of the dwarf signal is pressed once again in acknowledgement.

If a shunting route is used at a time when it conflicts with an already established shunting route, the control is *stored* and the route will not be established until the previously mentioned conditions exist. The points to be switched before the stored route is established are shown on flashing position-lamps.

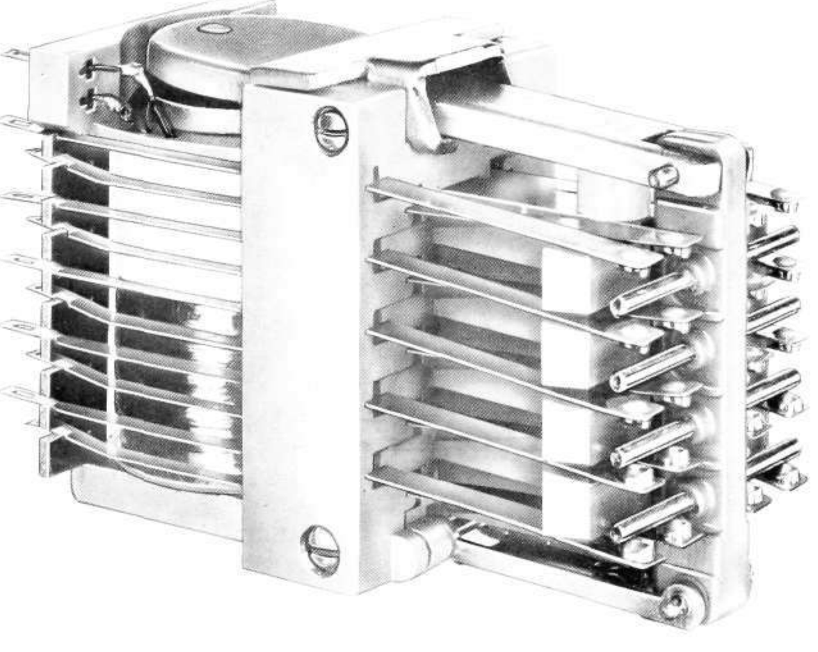


Fig. 8
Dansk Signal Industri's safety relay which is designed to ORE specifications

External dimensions: width × height × length
40 × 55 × 90 mm

Number of contacts:	10
Contact pressure:	20—25 g
Contact load:	0.5 A at 220 V AC and DC 3 A at 30 V
Contact resistance:	less than 0.04 ohm
Power consumption:	1.2—3.5 W
Test voltage:	2 000 V AC

The establishment of points for passage or protection, locking of signals on "No entry" etc., is automatically cancelled as the cut successively passes the track circuits on the shunting route.

"Free shunting". "Signal cancelled" can be displayed from each dwarf signal provided that the signal is not established or used as protective signal.

If a dwarf signal showing "Signal cancelled" is to be used for protection of a route, the signal is automatically switched to "No entry" until the route is released. A flashing light is then shown on the control panel for "No entry" as a sign that "Signal cancelled" has been stored. But despite the fact that the dwarf signal already displays "No entry", the signalling for the shunting route will not be established until the personnel have "acknowledged" by switching the signal to "No entry". The aim of this operation is that the personnel shall obtain assurance (probability) that a shunting movement towards the dwarf signal really respects "No entry".

In areas where free shunting is appropriate, there are local-operation buttons beside the points. As long as a point is released for local operation, automatic switching is prevented; individual central operation on the other hand is possible. Both with individual central operation and with local operation a check is made that the track circuit of the point is unoccupied.

Main route. The establishment of main routes takes place essentially on the same principles as stated above, with the exception that the track circuits after the end point of a route–corresponding at least to the safety distance for the route–must be unoccupied.

The routes are released automatically on the same principle as for shunting, but the emergency release has been made more restrictive through the use of timing relays among other means.

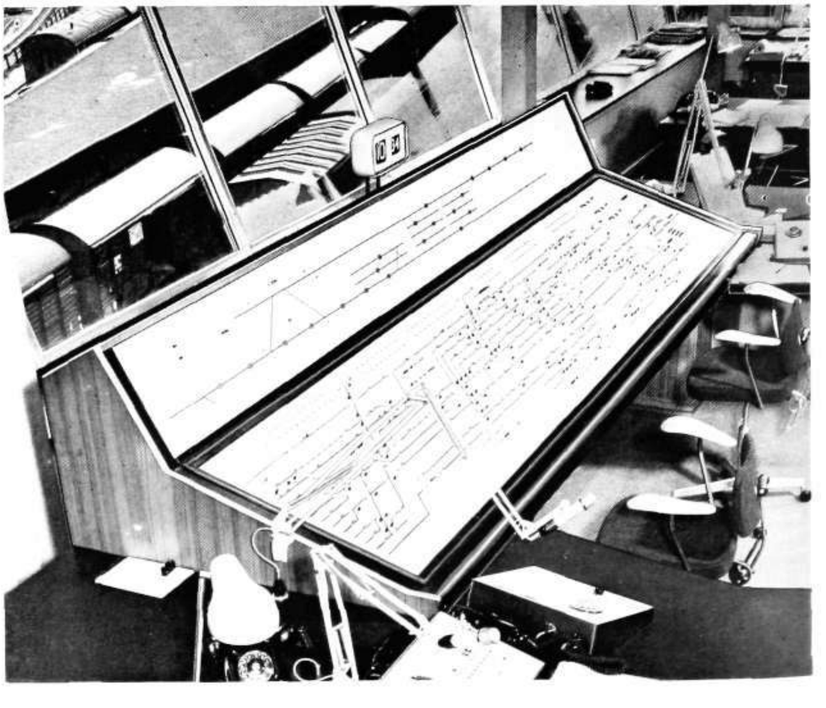


Fig. 9
Control machine at Copenhagen Main Station.

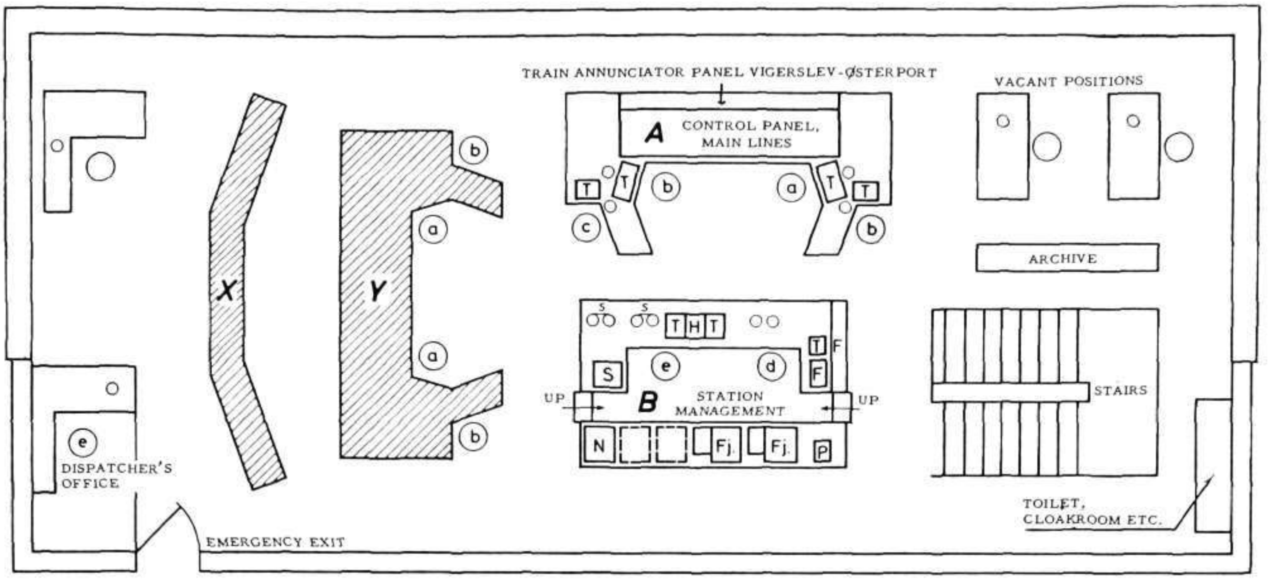


Fig. 10

Furnishing plan for control room at Copenhagen Main Station. The shaded items belong to the suburban line area and their design has not yet been decided on.

- A: Track diagram, main lines
- B: Train dispatching
- Y: Control panel for the entire suburban area
- X: Panel *for indication of train movements* in suburban yard area
- T: Telephone switchboard
- H: Selection of announcements for public address system
- S: Operation of train destination board
- F: Operation of train delay panel
- N: Train describer printer
- Fj: Teleprinter
- P: Recording of time of track occupation
- a: Responsible stationmasters
- b: Assistant to stationmaster
- c: Shunting master
- d: Train dispatcher for movements to and from Copenhagen Main Station
- e: Assistant to train dispatcher

Copenhagen Main Station—Signal Box Functions

The signal box in which the new type of plant is installed is planned for the takeover in due course of the supervision of the entire passenger railway traffic of the Greater Copenhagen area, both suburban and main lines.

The control room (fig. 10) is therefore arranged for this centralization, but for the time being the only equipment installed is that for main lines operation at Copenhagen Main Station; a number of future functions are, however, provided for.

The central part of the room is taken up by the control machine A, which is normally served by a *stationmaster* (a) and an *assistant* (b), who are responsible essentially for the shunting work at the western end of the station. The *shunting master* (c) directs the shunting engines by radio and works chiefly in collaboration with b, who is also in radio communication with the engines.

During periods of heavy traffic one position can be occupied by an additional assistant to the stationmaster.

The control machine can also be operated by the stationmaster alone, which is necessary during certain hours of the night.

In front of the control machine the floor is raised about 0.5 m and on the platform there is space for the duty superintendent (d) during heavy traffic hours. He is responsible for communication with the stations etc. with which Copenhagen Main Station has main contact. For the assistance of the duty superintendent and stationmaster there is an assistant at position (e) who is responsible for the automatic traingraph, teleprinter, train destination board, train delay panel, public address system etc.

The shaded items are intended for control of the entire Copenhagen suburban line plant. X is the indication panel on which the locations of individual trains on the roughly 160 km of track are registered by lamps. Y is the control panel on which the descriptions of individual trains are keyed by the stationmaster (a), after which the trains are automatically routed from the departure station to the terminal station.

It should be noted, however, that the final arrangements for the suburban line equipment have not yet been decided on.

Operational experience with plant type DSB 1964

In the presence of representatives from DSB and DSI the plant was commissioned on August 23, 1967, and the following weeks were used for connecting up and checking of the entire plant as regards both the interworking of individual relay sets and the communications with the control machine, track circuits, point machines, external signals and much else. The time was also used for training of the operating personnel.

It can now be established

that it is an invaluable advantage that all relay sets and internal cabling are mechanically tested before connection,

that is is an invaluable advantage that relays simulating point machines are used so that an interlocking plant can be tested in its entirety before it is connected to the actual point machines on the track. The external signals can usually all be connected up, but with covered lights.

The final cut-over of the plant took place on November 6, 1967, and the operational experience has been satisfactory.

The technical experience of the new type of plant may be summarized as follows.

It is *easier*, and it takes a much shorter time, to test and supervise the new type of plant than earlier plant on a corresponding scale. The reason for this is that one can fully rely on the automatic testing of relay sets, track cables and the like. If the new plant had been tested by the traditional methods, the internal dependencies of the relay sets alone would have required some 10 men working for 5 months.

The earlier troubles in maintaining the standardized minimum length of a track circuit *in advance of a point* have been overcome; this is to some extent unnecessary, as the new plant can be satisfactorily adapted to all existing track conditions, provided naturally that shunting always takes place on established routes. At Copenhagen Main Station there are several occasions when such track circuits at points have a length of 7 m, as the station track layout is too short and too narrow for the maximum quantity of traffic to be dealt with.

Fig. 11

Annunciator system Roskilde - Vigerslev-Copenhagen Main Station and Østerport.

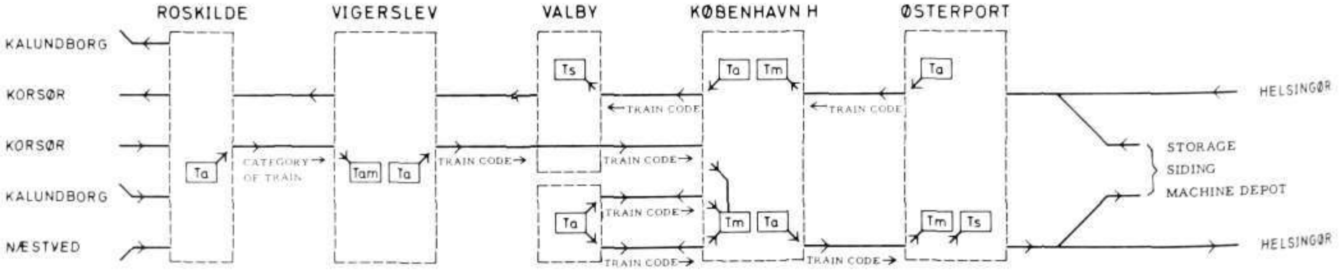
By means of differently coloured lights Roskilde announces the category of train (passenger or goods) dispatched to Vigerslev.
By means of two-digit train codes Vigerslev–Østerport announce a train approaching Copenhagen Main Station.
By means of a two-digit code Copenhagen Main Station announces a train to Valby or Østerport and the code is used, among other purposes, for control of the train destination boards at the stations.

Ta Keyset

Tam Train category announcement

Ts Train destination board

Tm Train code announcement



The *few operational requirements* which were overlooked before the plant was installed could be easily fulfilled without interfering with the handling of traffic.

Contact faults play an extremely small role. In all there were only about 20 contact failures out of 100,000 or more operating contacts. The establishment of main and shunting routes requires 1 million contact operations daily.

The extended use of factory-tested solder connections–in all some 100,000–proved efficient. Only one soldering fault has been discovered.

It is now also considered profitable to use the new type of plant for medium-sized installations despite the extra equipment required in conjunction with geographical circuitry. This is compensated by a saving on the very considerable drawing and supervisory work that has been necessary hitherto.

The new type of plant is expected also to be used for relatively small installations on the suburban lines.

Some Economic Aspects on the Long-Term Planning of Telephone Networks
Part II

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LME 8231

Part II of this paper deals with questions relating to number and locations of exchanges and to the traffic distribution between old and new exchanges in a multi-exchange network. Part I appeared in the preceding number of Ericsson Review.

Number and Locations of Local Exchanges, and Boundaries of Exchange Areas in a Multi-Exchange Area

When making long-term plans for telephone plant the determination of the correct number of exchanges and their locations is of great importance. The purpose of an exchange area study is to obtain the optimum economic combination of outside plant and switching equipment.

With few exchanges the exchange areas are large and the cost of subscribers' networks great. The cost of sites, buildings, basic switching equipment and junction network is comparatively small. With an increasing number of exchanges the cost of the latter items increases, while the cost of subscribers' networks decreases. Accordingly the sum of the costs for subscribers' networks, exchanges and junction network has a minimum.

Developments in new switching systems and subscriber growth stimulate the following questions

- Should existing exchanges be left where they are or moved to new locations?
- How many exchanges should be eliminated?
  This question is of particular interest for rural areas served by small manual switchboards and where an automatic telephone service is contemplated.
- How many exchanges should be added?
  This question is of particular interest for rapidly growing urban areas and for areas overflowing into fringe areas forming numerous suburbs.
- Where are the economical locations for new exchanges?

The Location of a Single Exchange within a Definite Area

In any study a basic requirement is to determine the location for an exchange within a definite area to give the minimum line plant costs. This location is known as the *optimum centre* and is determined by a detailed study of the costs involved in providing subscribers' line plant from a number of possible exchange sites.

																		S1	S2
5	10			10	10			3										38	
5		10			10				3									28	66
10		5			20				2			1	1					39	105
					30	30	3		4	3		5	5	5		5	1	91	196
10	10	10			30	30	4	10	5	5	5		5	5	5	5	5	144	340
	10		10	10	30	30	3	10	5	5	5	5	3	5	5	5	5	146	486
	10		10	10	30	20	3	10	10	5	◄	5	5	2	5	5	5	135	621
				10					5	5	5	5	5		5	5	5	50	671
	20	20	20		10		10				1	3	2		3	5	2	96	767
	20	20			10	10	10											70	637
		20	20		10	20	30											100	937
	20	20		10	10	30	30	10										130	1067
		10	10			10	10	10										50	1117
		10	10	10	▲	1												31	1148
30	100	125	80	60	200	181	103	53	34	23	16	24	26	17	23	30	23		
	130	255	335	395	595	776	879	932	966	989	1005	1029	1055	1072	1095	1125	1148		

Fig. 8

Determination of the theoretical centre

S1 — Individual sums of lines or columns
S2 — Addition of the individual sums

Total number of lines = 1148

The theoretical centre is at about 1148:2 = 574

It is at the intersection of the S2 values of the rows and columns (shown by arrows)

To limit the number of possible alternatives, it is desirable to be able to determine a *theoretical centre* near which the optimum centre will be. This theoretical centre is, as known, obtained by using a scaled map of the exchange area divided into squares of equal size into which a long-term forecast is distributed (subscriber inventory). A vertical line is drawn in such a position that it divides the forecast into two equal parts. A similar horizontal line is then drawn. The point of intersection of the two lines is the theoretical centre, see fig. 8.

The optimum centre depends on the actual and proposed cable routes in the exchange area and is obtained by considering possible locations of the exchanges along these routes.

The actual exchange site selected usually differs from the optimum centre depending on site availability, price of available site and local building regulations.

Number and Locations of Exchanges and Boundaries of Exchange Areas

The Method

The number of exchanges is determined by economic comparison. Some different assumptions are made as to the number of exchanges. For each number the exchange locations and boundaries are determined and the cost of subscribers' networks calculated. To this cost are added the cost of sites, buildings and switching equipment and, finally, the cost of the junction circuits obtained according to "The Junction and Trunk Networks" (below). In this way a number of sub-optima are obtained and the most convenient solution can be chosen.

The number of exchanges which according to this cost comparison gives the lowest cost is not always the solution to be chosen. Solutions involving one or more long and narrow exchange areas should as far as possible be avoided. The forecasts are always more or less inaccurate and unforeseen developments far from the exchange may lead to heavy costs for extending the primary network. A curve of the costs as a function of the number of exchanges generally displays a flat minimum, so that a convenient solution can often be found in the neighbourhood of the theoretical minimum with a (theoretical) cost increase of less than ½ %. Finally the minimum is flatter for an increasing than for a decreasing number of exchanges and it is therefore better to choose too many exchanges than too few. This implies that if, as is highly desirable, studies are made under different assumptions regarding the subscriber increase, more weight should be attached to the results for the greatest assumed subscriber increase.

The locations and boundaries are determined by an iterated process. To start with, the exchange locations are estimated on trial and the corresponding boundaries are determined. The boundaries are used to determine new exchange locations. These new exchange locations are used to obtain new boundaries, and so on. This process is conveniently done on an electronic computer.

The locations of the exchanges and the boundaries of the exchange areas found in this way have to be adjusted with regard to the topography and the existing outside plant. The best boundary is often a natural one – e.g. a river, a railroad or a highway – and should be considered when making the final decision.

Requisite Data

The requisite data for these calculations are:

- *The forecasts*

  A long-term subscriber forecast for the studied area, distributed into squares of equal size, see fig. 8

  A long-term forecast of the traffic between different areas

- *Provision cost*

  Cost of different types of main and junction cables per unit of length

  Cost of switching equipment and terminals

  Cost of sites and buildings

- *Transmission properties of telephone sets and cables (loaded or unloaded)*

- *Limiting factors*

  Transmission plan and signalling limits

  Traffic losses (grade of service)

- *Present state of network*

  Existing exchanges and switching system

  Conduit system

  Main cables

  Junction network

The Point of Time for the Installation of a New Exchange

Once the location of an exchange has been determined by means of a long-term forecast on the principles mentioned above, it is necessary to establish *when* the exchange should be added. This involves making detailed comparisons of the present value of annual charges *using different assumed years* for installing the exchange over a 20–30 year period, first serving the area by an existing feeder route or routes from one or more existing exchanges and then serving the same area from the combination of existing routes and exchanges with one or more exchanges added.

Such a study entails comprehensive numerical calculations which, however, soon will be facilitated with by programming for a computer.

Traffic Distribution between Old and New Exchanges in a Multi-Exchange Area

In a growing urban area new exchanges are added and exchange boundaries are altered. For the planning of the junction network it is necessary to establish the inter-exchange traffic resulting from the new division into exchange areas.

The calculation of the new traffic distribution may be done in the following two steps.

- Estimation of the traffic between existing exchange areas. Three methods for such estimates were described under the section *Forecasts* (Part I)
- Transformation of the traffic distribution between existing exchanges into a traffic distribution relating to a new future division into exchange areas. This implies no forecasting and is an entirely mathematical procedure.

Introduce the following designations

$N_i^{(k)}$ = number of subscribers in the new exchange area i previously contained in the exchange area k

$\varepsilon_{kl} = \dfrac{A_{kl}}{N_k \cdot N_l}$ = community of interest factor between the area k and l (calculated on the basis of the forecast for existing areas, see Part I, *Forecasts*)

Then the traffic distribution, A_{ij}, between the exchanges (new and old) is see Part I, *Forecasts*)

$$A_{ij} = \sum_{k,l} N_i^{(k)} \cdot \varepsilon_{kl} \cdot N_j^{(l)} \tag{11}$$

$k, l = 1, 2, \ldots, s$ $\quad s$ = actual number of exchanges ($t = 0$)

$i, j = 1, 2, \ldots, r$ $\quad r$ = number of exchanges ($t = T$)

As an example assume that two new exchanges 4 and 5 are to be formed by detachment from the existing areas 1, 2, 3. The new traffic distribution is then obtained from the matrix product

$$A_{ij} = \begin{bmatrix} q_1 & 0 & 0 \\ 0 & q_2 & 0 \\ 0 & 0 & q_3 \\ p_{14} & p_{24} & p_{34} \\ p_{15} & p_{25} & p_{35} \end{bmatrix} \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \begin{bmatrix} q_1 & 0 & 0 & p_{14} & p_{15} \\ 0 & q_2 & 0 & p_{24} & p_{25} \\ 0 & 0 & q_3 & p_{34} & p_{35} \end{bmatrix} \tag{12}$$

where

$$q_1 = \frac{N_1^{(1)}}{N_1} \qquad q_2 = \frac{N_2^{(2)}}{N_2} \qquad q_3 = \frac{N_3^{(3)}}{N_3}$$

$$p_{14} = \frac{N_4^{(1)}}{N_1} \qquad p_{24} = \frac{N_4^{(2)}}{N_2} \qquad p_{34} = \frac{N_4^{(3)}}{N_3}$$

$$p_{15} = \frac{N_5^{(1)}}{N_1} \qquad p_{25} = \frac{N_5^{(2)}}{N_2} \qquad p_{35} = \frac{N_5^{(3)}}{N_3}$$

A_{kl} = traffic between existing areas ($k, l = 1, 2, 3$)

N_k = number of subscribers in existing exchange areas ($k = 1, 2, 3$)

A_{ij} = traffic between the future exchanges ($i, j = 1, 2, 3, 4, 5$)

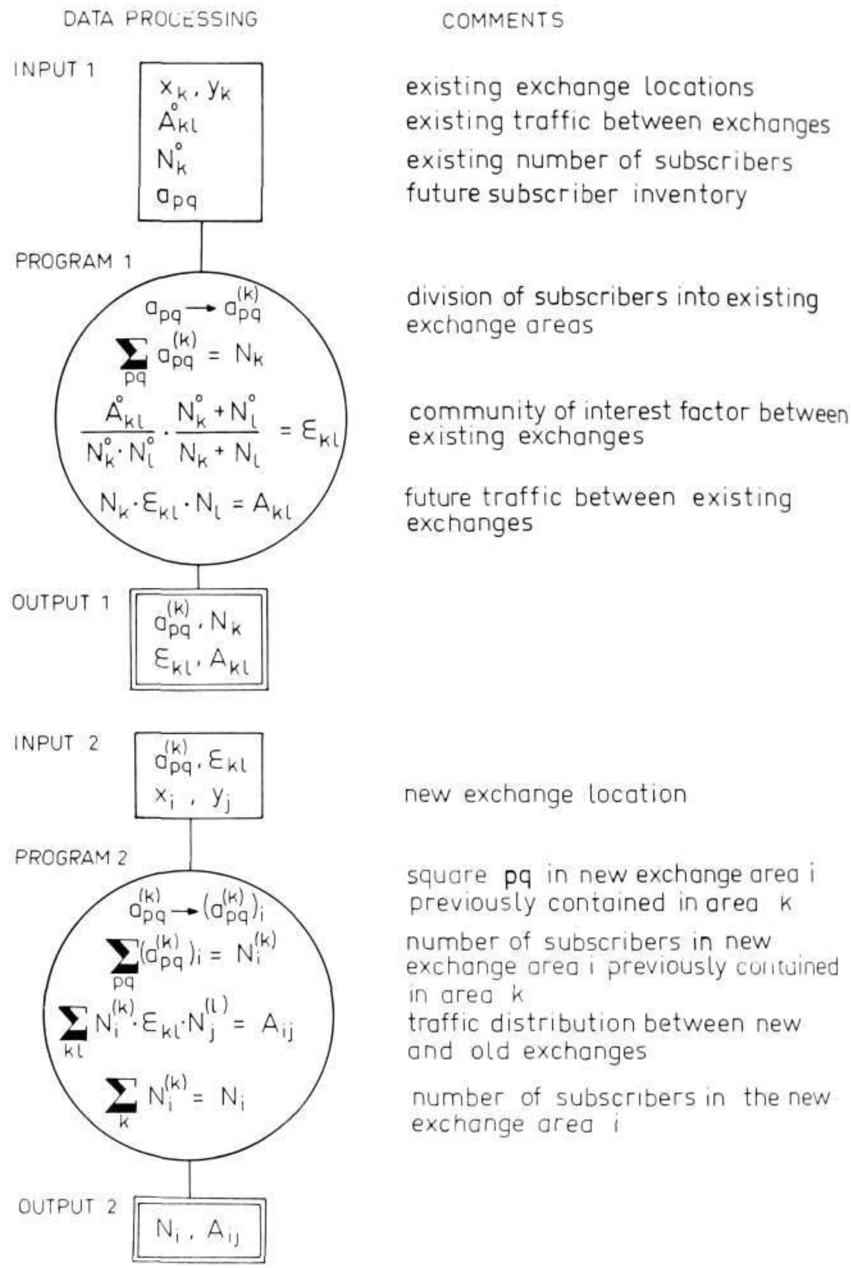


Fig. 9
Transformation of traffic distributions
Survey of calculation steps

The determination of the inter-exchange traffic between existing and future exchange areas implies considerable numerical calculations especially for areas with many exchanges.

The use of a computer for these calculations therefore saves time and money.

Fig. 9 gives a survey of such calculations made with the aid of the subscriber inventory (cf. fig. 8) and other relevant data.

In this figure the traffic between existing exchange areas is taken as point of departure for the calculations. Alternatively the calculations may start with the traffic between any well defined areas.

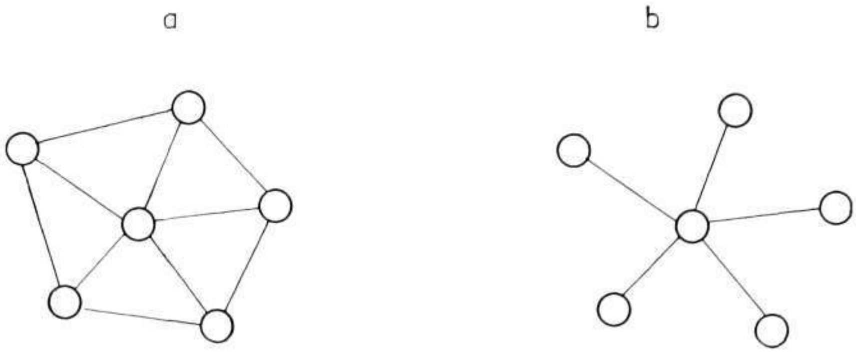


Fig. 10
Possible layouts of the cable runs in a junction network

The Junction and Trunk Networks

A glance at a layout for an alternative routing network shows that the circuits between the exchanges

- are assembled on certain paths, called cable runs
- are connected according to a certain pattern or routing doctrine
- are of different types, such as physical and carrier circuits.

As a matter of fact an alternative routing network can be exhaustively described by the following data

□ *The cable run matrix* showing the distances between adjacent switching points or nodes in the network. This matrix describes the permissible routes in the network to be followed for the junctions between exchanges and tandem stages. Thus the exchanges coincide with the "vertices" of a graph, the cable runs with the "arcs" and a route is a chain of cable runs which can be defined by an ordered sequence of exchange numbers.

Fig. 10 shows two examples of possible layouts of the cable runs between the exchanges. If the traffic between the exchanges is great, a layout according to fig. 10a may prove to be the best solution. But if the traffic between the exchanges is small, a layout according to fig. 10b may be advantageous.

□ *The junction matrix* depicting the division of the exchanges into tandem areas and the possible routes between the exchanges, first choice, second choice, third choice etc.

Fig. 11 shows the division into tandem areas for two junction networks. The number of subscribers is of the same order of magnitude, 500,000–

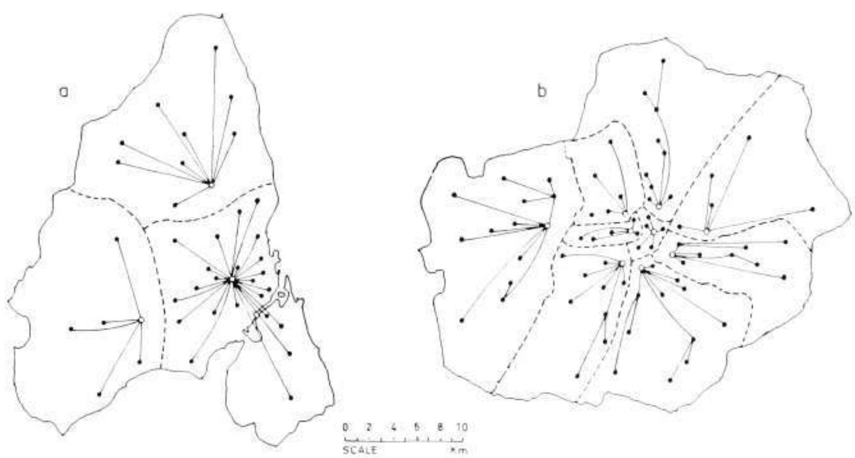


Fig. 11
Division into tandem areas for two large networks

○ **Tandem exchange**
● **Local exchange**
– – – **Tandem area**

750,000, but the number of tandem areas is 3 for one area and 11 for the other. This fact gives a hint that no general rule for division into tandem areas can be given and that a detailed investigation must be made for each particular case.

In practice, however, the total costs of the network do not change very much with changes in the number and location of the tandem stages and therefore there is a certain freedom in establishing a tandem network.

For a country which is on the point of introducing modern automatic switching systems it is also of interest to note that considerable changes in the routing and numbering scheme will be economically justified, especially for rural networks. For such networks the numbering areas will generally be greatly extended and, consequently, also the length of local numbers in country areas. In this way the trunk and local networks are linked together and the number of tandem stages and switching centres reduced.

Fig. 12 shows as an example a junction diagram for 9 exchanges and 3 tandem stages. Here

- exchanges 1, 2, 3 belong to tandem area 10
- ,, 4, 5, 6, 7 ,, ,, ,, ,, 12
- ,, 8, 9 ,, ,, ,, ,, 11

This diagram may be represented by the two matrices shown in the same fig. 12.

Tandem stages may, but need not necessarily, be placed in the exchanges.

The cable run matrix and the junction matrix together define the *structure* of the network.

□ *The route matrix* containing a specification of the types and number of junctions on the routes between any two exchanges and cable runs in the network together with the *class* of the junctions, viz

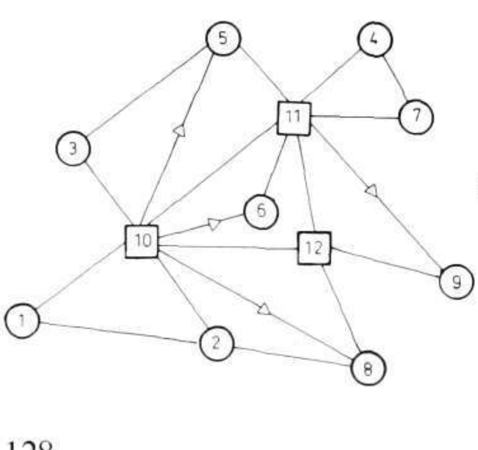
t = tandem

d = direct

h = high usage

Fig. 12
Example of a junction diagram and the corresponding junction matrices

t = tandem circuits h = high usage circuits
d = direct circuits ▷ = one-way traffic



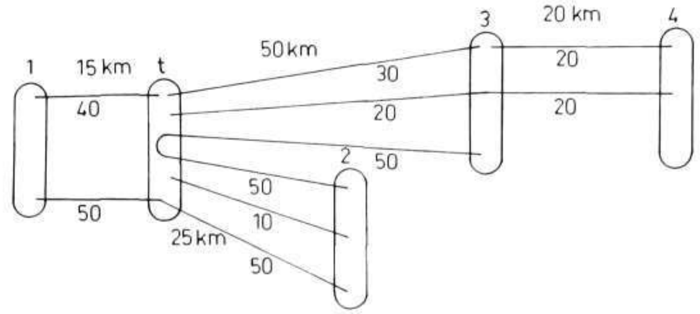
A junction diagram

	1	2	3	4	5	6	7	8	9
1	–	d	t	t	t	t	t	t	t
2	d	–	t	t	t	t	t	h	t
3	t	t	–	t	h	t	t	t	t
4	t	t	t	–	t	t	h	t	t
5	t	t	h	t	–	t	t	t	t
6	t	t	t	t	t	–	t	t	t
7	t	t	t	h	t	t	–	t	t
8	t	h	t	t	t	t	t	–	t
9	t	t	t	t	t	t	t	t	–

10	d	d	d	t	h	h	t	h	t
11	t	t	t	d	d	d	d	t	h
12	t	t	t	t	t	t	t	d	d

The corresponding junction matrices

a.



b.

Cable run matrix

distance between adjacent nodes

	1	2	3	4	t
1	–				15
2		–			25
3			–	20	50
4				–	
t					–

c.

Junction matrix

	1	2	3	4
1	–	h	t	t
2		–	h	t
3			–	d
4				–

d = direct low loss circuits
t = tandem circuits
h = high usage circuits

d.

Route matrix

Route	Number of junctions	Class of junction	Type of junction on cable run			
			1 - t	2 - t	3 - t	3 - 4
1 - t	40	t	ph 0.7			
1 - 2	50	h	ph 0.5	C		
2 - 3	50	h		C	C	
2 - t	10	t		C		
3 - t	30	t			C	
3 - 4	20	d				ph 0.6
t - 4	20	t			C	ph 0.8
Number of circuits on cable runs			90	110	100	40
Type of carrier				C(120)	C(120)	

ph 0.7 = physical circuits conductor diameter 0.7 mm   C(120) = 120-channel carrier system

Fig. 13
Cable run matrix, junction matrix and route matrix for a network with four exchanges and one tandem stage

We note that a route is fully described only with all the following information

- the path (an ordered sequence of node numbers)
- the number of circuits between sending and receiving exchange or tandem stage
- the types of circuits on the different cable runs contained in the route
- the class of junction (*t*, *h* or *d*)

Fig. 13 a–d illustrates the above-mentioned concepts.

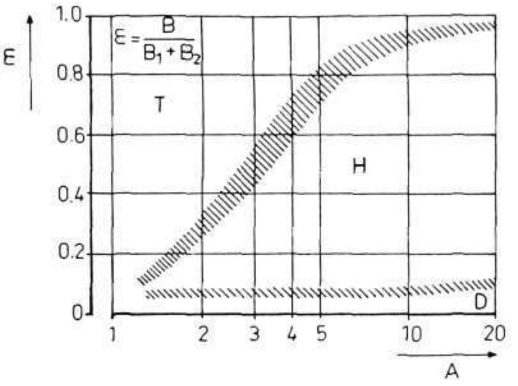


Fig. 14
The THD diagram

T, H, D = domain of employment for tandem, high usage and direct circuits respectively as a function of the offered traffic, A, between the exchanges and the cost ratio, ε, between high usage and tandem circuits.
Min. number of circuits on high usage routes = 4

Fig. 13 a shows the routes and cable runs in a network of four exchanges and one tandem stage.

Fig. 13 b gives the cable run matrix.

Fig. 13 c gives the junction matrix.

Fig. 13 d gives the route matrix.

The planning of a junction network implies the determination of all the above-mentioned data, viz.

- the cable run matrix, which determines the permissible paths in the network
- the junction matrix, depicting the routing philosophy
- the route matrix, giving the types and number of junctions on all cable runs and routes.

Thus the cable run matrix depicts the topography, the junction matrix the topology, and the route matrix gives the specification of the network.

A simultaneous optimization of all variables mentioned above is not possible. Iterative methods have to be used and the network must be planned

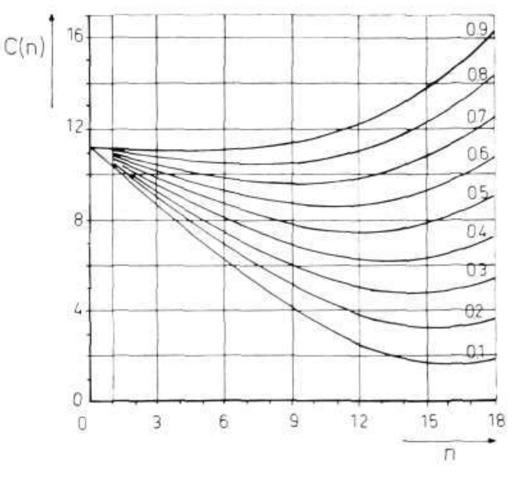


Fig. 15
Example of the cost C(n) for carrying a traffic of 10 erlangs on high usage and tandem routes as a function of the number, n, of high usage junctions

Cost ratio $\varepsilon = \frac{B}{B_1 + B_2} = 0.1, 0.2, \ldots, 0.9$

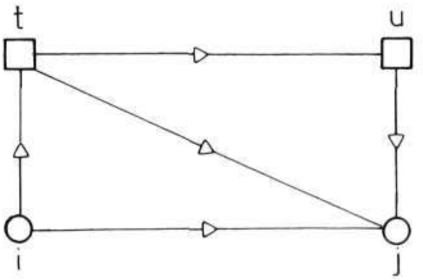


Fig. 16

Traffic flows in a network with three choices

P_{ij} = traffic rejected from the high usage route ij
P_{tj} = traffic rejected from the high usage route tj

Traffic on the route it: $A_{it} = \sum_{j} P_{ij}$
i.e.
he sum of the rejected traffics from i to all other exchanges.

Traffic on the route tj: $A_{tj} = \sum_{i \epsilon t} P_{ij}$
i.e.
the sum of the rejected traffics from all exchanges in tandem area t to exchange j in tandem area u

Traffic on the route tu: $A_{tu} = \sum_{j \epsilon u} P_{tj}$
i.e.
the sum of the rejected traffics from all routes between the tandem stage t and all exchanges in tandem area u

Traffic on the route uj: $A_{uj} = \sum_{i \epsilon u} P_{ij} + \sum_{t \neq u} P_{tj}$
i.e.
the sum of the rejected traffic from all exchanges in tandem area u to exchange j in the same area plus the rejected traffics from other tandem stages than u to the same exchange j

under different assumptions regarding the *structure* of the network. For each such assumption the number of junctions has to be determined in such a way that the total costs are as low as possible.

Besides the cable run and junction matrices the requisite data for the calculation of the number of circuits are:

- offered traffic between the exchanges
- incremental costs of junction circuits
- the grade of service.

The grade of service may be defined as the overall average congestion or as the average congestion of the traffic offered to the overflow group.

Class and Number of Circuits

The class of circuit to be used between two exchanges–tandem (T), high usage (H) or direct (D) circuits—is predominantly determined by the offered traffic, A, between the exchanges and the cost ratio

$$\varepsilon = \frac{B}{B_1 + B_2} \qquad (13)$$

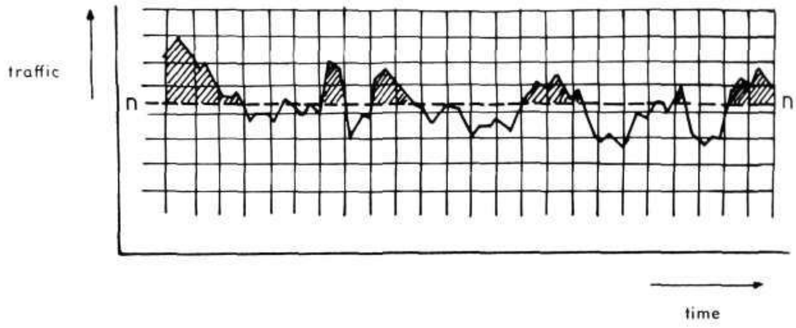
between the incremental cost for direct and tandem circuits. Fig. 14 shows as example the kind of circuit to be used, T, H or D, as a function of the offered traffic and the cost ratio on condition that the number of circuits on the high usage junction is at least four.

On the routes where high usage junctions will be used the *number of high usage junctions* must be calculated in such a way that the sum of the costs for high usage junctions and tandem junctions is as low as possible.
As an example, fig. 15 shows the cost for an offered traffic of 10 erlangs as a function of the number of high usage junctions for different values of the cost ratio.

For the determination of the number of high usage junctions the following approximate formula has been widely used

$$F(n, A) = A[E(n, A) - E(n + 1, A)] = \eta \cdot \varepsilon \qquad (14)$$

Fig. 17
Character of the traffic rejected from a high usage route



where

n	= number of high usage circuits
A	= offered traffic between the exchanges
$F(n, A)$	= the "improvement" function, i.e. the increase of the traffic carried by high usage junctions on an increase in the number of high usage junctions from n to $n + 1$
η	= the efficiency of incremental trunks (marginal utilization of magnitude 0.6–0.8)
ε	= cost ratio (see eq. 13)

However, this formula has the disadvantage of giving too many high usage circuits if the cost ratio is high and/or the traffic is small.

A better approximation is obtained by the formula

$$F(n, A) = \varepsilon \cdot [1 - 0.3(1 - \varepsilon^2)] \tag{15}$$

which is fitted to the result of extensive calculations on a computer.

When the number of high usage junctions has been determined, a calculation of *the traffic offered to all routes in the network* is possible.

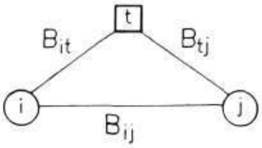
As an example consider a network with 3 choices built up according to fig. 16 where

i	= sending exchange in tandem area t
j	= receiving exchange in tandem area u
i–j	= first choice
i–t–j	= second choice
i–t–u–j	= third choice

In fig. 17 the traffic rejected from a high usage route with n circuits is represented by the shaded areas above the line n–n. Obviously traffic of this kind assembled on a tandem route is not of the same type as the traffic offered to a high usage route and cannot be described only by its mean value. Also the variances of the traffic must be taken into account.

A method for determining *the number of circuits on high usage and tandem routes* using Wilkinson's equivalent random theory, and approximate formulae derived therefrom, is shown in fig. 18 together with a numerical example. This method is convenient for determining the structure of the network and the number of high usage circuits. However, full availability being assumed, corrections of the number of tandem circuits may be necessary depending on the particularities of the system employed.

Numerical example



Basic data:

Traffic between the exchanges

A_{ij} =

	1	2	3	4
1	–	35	60	25
2	30	–	15	5
3	52	17	–	10
4	20	6	12	–

Incremental cost for junctions

B_{ij} =

	1	2	3	4	B_{it}
1	–	1747	1802	1416	1140
2	1747	–	2410	1968	1747
3	1802	2410	–	2078	1802
4	1416	1968	2078	–	1416
B_{tj}	1140	1747	1802	1416	–

Grade of service on tandem routes $E_0 = 0.005$

Calculations:

Cost ratio $\varepsilon_{ij} = \dfrac{B_{ij}}{B_{it} + B_{tj}}$

ε_{ij} =

	1	2	3	4
1	–	0.605	0.613	0.554
2	0.605	–	0.679	0.622
3	0.613	0.679	–	0.646
4	0.554	0.622	0.646	–

Number of high usage junctions n_{ij}

$A_{ij} \cdot (E(n_{ij}) - E(n_{ij}+1)) = \varepsilon_{ij} \cdot (1 - 0.3 \cdot (1 - \varepsilon_{ij}^2))$

n_{ij} =

	1	2	3	4
1	–	37	63	28
2	32	–	15	5
3	55	17	–	10
4	22	6	12	–

Mean value of traffic rejected from the high usage routes.

$$P_{ij} = A_{ij} \cdot E(n_{ij})$$

P_{ij} =

	1	2	3	4	M_{it}
1	–	3.22	4.11	2.07	9.40
2	2.89	–	2.70	1.42	7.01
3	3.70	2.90	–	2.15	8.75
4	2.13	1.59	2.38	–	6.10
M_{tj}	8.72	7.71	9.19	5.64	–

Variance of rejected traffic from the high usage routes.

$$V_{ij} = P_{ij} \cdot \left[1 - P_{ij} + \frac{A_{ij}}{1 + n_{ij} + P_{ij} - A_{ij}}\right]$$

V_{ij} =

	1	2	3	4	V_{it}
1	–	10.97	17.62	6.31	34.90
2	9.26	–	6.36	2.34	17.96
3	15.00	7.13	–	4.35	26.48
4	5.90	2.74	15.16	–	13.80
V_{tj}	30.16	20.84	29.14	13.00	–

Equivalent traffic $\overset{*}{A}_{it} = V_{it} + 3 \cdot \dfrac{V_{it}}{M_{it}} \left[\dfrac{V_{it}}{M_{it}} - 1\right]$ $\overset{*}{A}_{tj} = V_{tj} + 3 \cdot \dfrac{V_{tj}}{M_{tj}} \left[\dfrac{V_{tj}}{M_{tj}} - 1\right]$

$\overset{*}{A}_{it}$ =

	t
1	65.12
2	29.97
3	44.93
4	22.37

$\overset{*}{A}_{tj}$ =

t	55.67	34.65	49.79	22.02

Fig. 18

Determination of the number of circuits on high usage and tandem routes in an alternative routing network with one tandem stage (2 choices)

The following method for determining the number of junctions on high usage and tandem routes is founded on theories and methods presented in

Wilkinson, R.I.:

Theories for Toll Traffic Engineering in the U.S.A. Bell Syst. Tech. J. 35(1956):2, pp. 421—514

and

Rapp, Y.: Planning of Junction Network in Multi-exchange Area. I. General Principles. Ericsson Tech. 20(1964):1, pp. 77—130.

Requisite data:

A_{ij} = offered traffic from exchange i to exchange j

B_{ij}, B_{it}, B_{tj} = incremental cost for junctions between exchanges and between exchanges and the tandem stage

E_0 = grade of service on the tandem routes

Fig. 18 cont.

Equivalent number of circuits $n^*_{it} = \dfrac{A^*_{it}}{1 - \dfrac{1}{1 + \dfrac{V_{it}}{M_{it}}}} - M_{it} - 1$

$n^*_{it} =$

	t
1	60.10
2	25.45
3	39.34
4	18.31

$n^*_{tj} =$

	1	2	3	4
t	50.93	29.62	43.98	18.55

Number of tandem circuits $E_o \cdot M_{it} = A^*_{it} \cdot E(n^*_{it} + m_{it}, A^*_{it})$

$m_{it} =$

	t
1	30
2	22
3	26
4	18

$m_{tj} =$

	1	2	3	6
t	28	23	27	18

TOTAL COST

Cost of high usages junctions

	1	2	3	4
1	—	37	63	28
2	32	—	15	5
3	55	17	—	10
4	22	6	12	—

×

	1	2	3	4
1	—	7147	1802	1416
2	1747	—	2410	1968
3	1802	2410	—	2078
4	1416	1968	2078	—

=

	1	2	3	4	Total
1	—	64639	113526	39649	217813
2	55904	—	36150	9840	101894
3	99110	40970	—	20780	160860
4	31152	11808	24936	—	67896

Total 548463

Cost of tandem circuits

	t
1	30
2	22
3	26
4	19

×

	t
1	1140
2	1747
3	1802
4	1416

=

	t
1	34200
2	38434
3	46852
4	26904

Total 146390

	1	2	3	4
t	28	23	27	18

×

	1	2	3	4
t	1140	1747	1802	1416

=

	1	2	3	4	Total
t	31920	40181	48654	25488	146243

Total cost of junctions and circuits 548463 + 146390 + 146243 = 841096

With the aid of the traffic flows in the different parts of the network the number of junctions on the tandem routes can be calculated by means of the predetermined grade of service (cf. fig. 18) and the part of the costs which depends on the number of junctions only.

To these costs are added the basic costs for a specific structure of the network and, by comparison with other layouts, a convenient solution may be chosen with regard to costs and overloading capability.

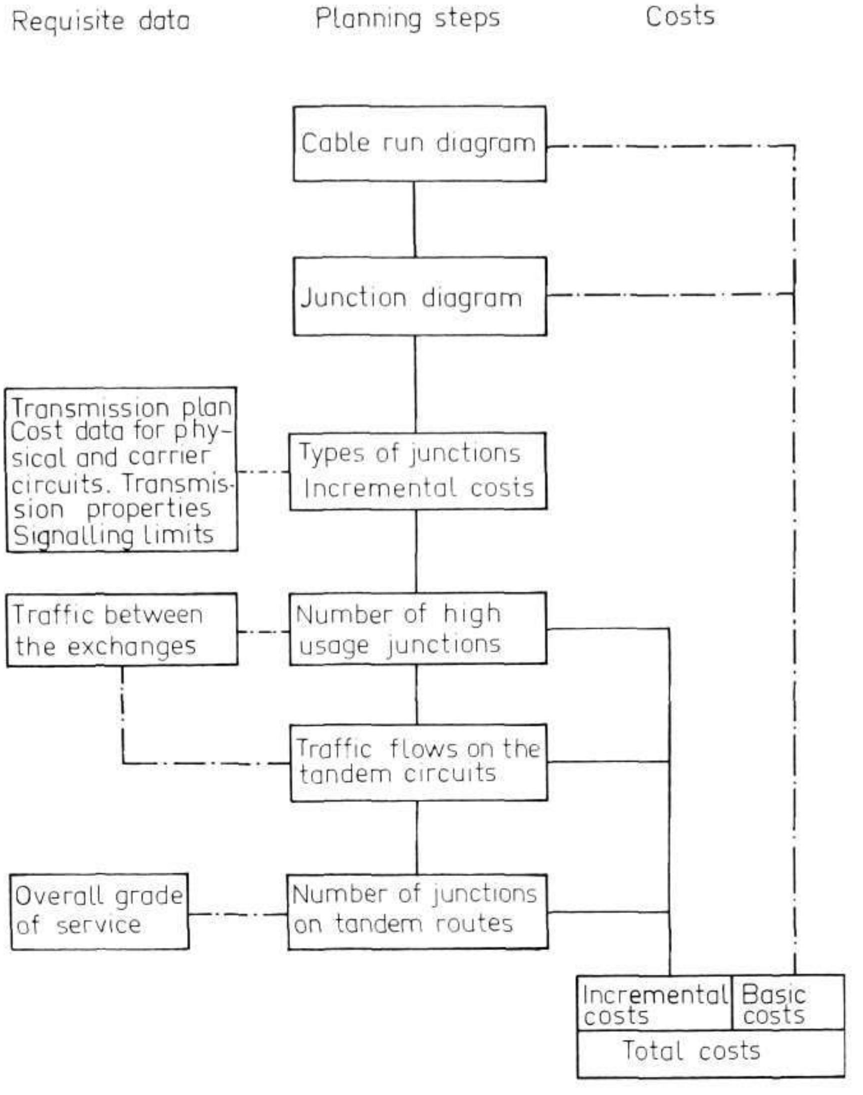


Fig. 19
Flow diagram showing essential planning steps in the layout of junction networks

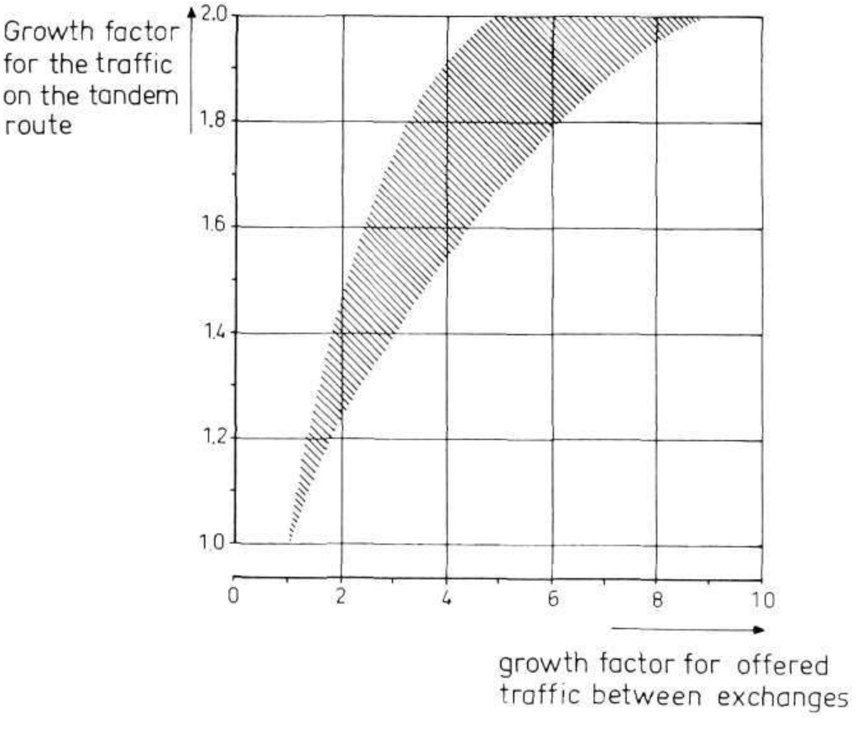


Fig. 20
Growth factor for the traffic on the tandem route as a function of the growth factor for the traffic offered to the high usage routes

$2 \leq A_0 \leq 20$ A_0 = initial initiated traffic
$0.5 \leq \varepsilon \leq 0.8$ ε = *cost ratio (see eq. 13)*

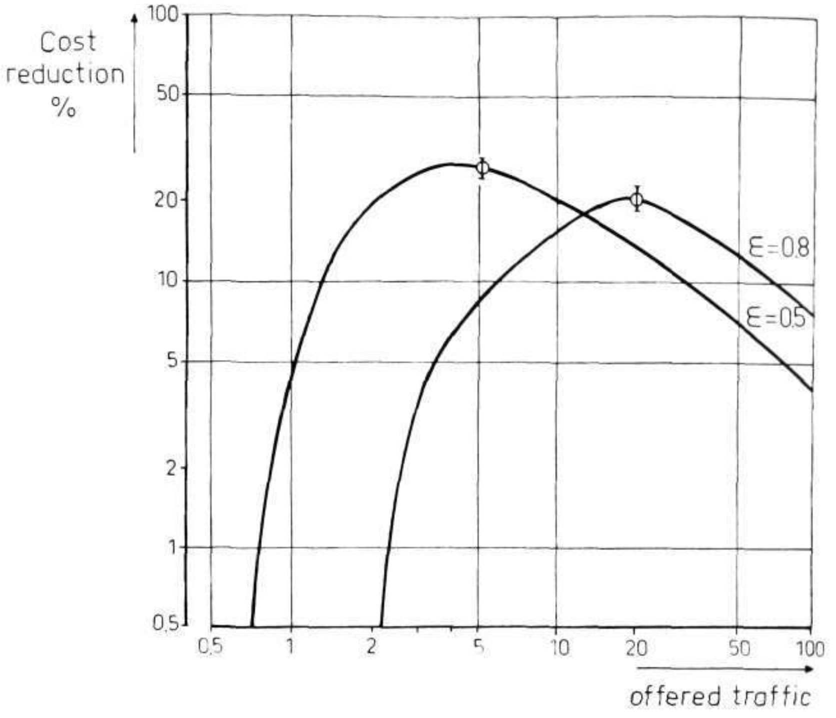


Fig. 21

Alternative routing versus low loss routing. Percent cost reduction as a function of offered traffic between the exchanges

Cost ratio $0.5 \leq \varepsilon \leq 0.8$

Efficiency of incremental trunks $\eta_i = 0.8$

To the left of the points Φ tandem routing cheapest low loss alternative

To the right of the points Φ direct routing cheapest low loss alternative

The steps in junction network planning are summarized in fig. 19.

The traffic between the exchanges generally increases with time and the study should therefore be based on forecasts for 5, 10, 15 . . . years so that the junction network may be extended in stages in an economical way.

Such studies show that the traffic on the tandem routes does not increase proportionally to the traffic between the exchanges but much more slowly.

Fig. 20 depicts this fact, which is of importance for provision planning and for determining the capacity of the tandem exchanges and size of exchange buildings.

From fig. 21 it is seen that for normal cost ratios 0.5–0.8 the economy of introducing alternative routing is small when the offered traffic between the exchanges is less than 1–2 erlangs or greater than 100 erlangs but may be considerable in the range 2–50 erlangs. This diagram is made up on the condition that the "busy hours" for the traffic between the exchanges coincide. If this is not the case, appreciable savings may be obtained also for high traffic values. However, if the traffic is very small and the cost ratio high, no savings can be gained from alternative routing as the economic number of high usage junctions in such case is zero.

Finally one has to consider that an alternative routing network decreases the risk of interruptions caused by technical faults and thus gives a better service.

ERICSSON News from All Quarters of the World

On September 11 Teleindustria S.A. de C.V. (TIM) produced its 100,000th Dialog. The president of TIM, Mr. Nils Kjellander (on far left), gathered together the personnel to thank them for their work.

LM Ericsson's Engagements in the Olympic Games in Mexico

Enormous amounts of money have been spent on creating as efficient and complete a telecommunications system as possible for the XIX Olympic Games. L M Ericsson have been heavily engaged in this assignment. In addition to the Ericsson subsidiary company in Mexico, several divisions, departments and subsidiaries in Sweden have been involved. A very brief account is given below of L M Ericsson's engagements in Mexico in recent times–with the main emphasis on the Olympic Games.

■ I July 1967 L M Ericsson received from its largest customer in Mexico, TELMEX (Teléfonos de México S.A.), a commission to build a 5000-line local telephone exchange for the athletes and others quartered in the Olympic Village. The work was completed, as far as L M Ericsson was concerned, in May this year.

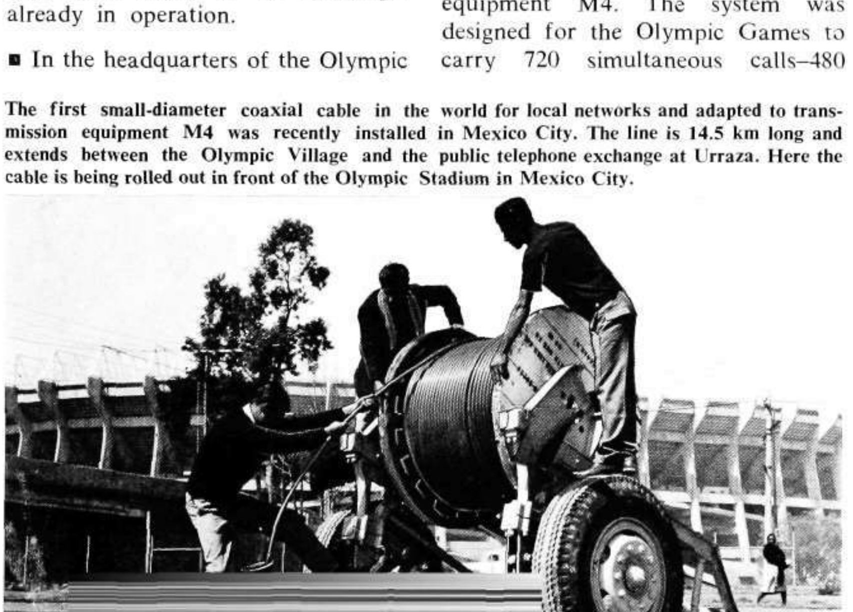
Within the telephone exchange field four new local telephone exchanges have also been supplied for Mexico City, serving some 30,000 lines, as well as extensions to some ten exchanges already in operation in Mexico City.

As regards trunk exchanges, L M Ericsson has contracts for the majority of these exchanges. In this case as well, large additions of equipment have been made to ten exchanges already in operation.

■ In the headquarters of the Olympic Games Committee, from which the Games are largely administered, the President of the Olympic Games, Sr. Pedro Ramirez Jazques, has a DYA 111 equipment supplied by L M Ericsson Telemateriel AB (LMS). This is a telephone attendance and conference system which provides direct connection with various athletic grounds or administrative centres. Only one telephone is required–in this case an Ericofon. The DYA system is associated with a PABX connected to the permanent network.

■ Between Pedregal, the Olympic Village, and the telephone exchange at Urraza—a distance of 14.5 km–runs the world's first small-diameter coaxial cable designed for a local network and adapted to transmission equipment M4. The system was designed for the Olympic Games to carry 720 simultaneous calls–480 direct circuits for the Olympic Village –but the system can without difficulty be converted for 5400 circuits.

The first small-diameter coaxial cable in the world for local networks and adapted to transmission equipment M4 was recently installed in Mexico City. The line is 14.5 km long and extends between the Olympic Village and the public telephone exchange at Urraza. Here the cable is being rolled out in front of the Olympic Stadium in Mexico City.



■ Most of the larger athletic grounds, billets, offices etc. have been equipped with L M Ericsson private exchanges, both manual and PAX/PABX. ARD 151 or AKD 860 have been used for the Olympic Games Committees and Olympic Villages.

■ Special requirements, naturally, are placed on the telecommunication equipment at the press headquarters. From there temporary telephone circuits run to adjacent public telephone exchanges. TELMEX has ordered for this purpose a number of 60-channel radio link systems, the multiplex equipments of which were supplied by L M Ericsson.

Large orders for multiplex equipments for the Mexican long-distance network have also been placed in recent years, among which the first government order. This was for an equipment for a radio link system from Mexico City north-east up to the United States border.

■ The television broadcasts from the Olympic Games are sent both via satellite and on microwave links throughout the world. For one of these links the transmission between two frontier cities in Mexico and the United States takes place via a cable for which L M Ericsson supplied the repeater equipment on the Mexican side.

■ Outside the field of telecommunications as well L M Ericsson has entered into the Olympic picture–some of the Olympic Games staff have their working times recorded on LMS time recorders.

News from Ericsson do Brasil (EDB)

■ Record Cut-over at Belo Horizonte

An ARF exchange for no less than 30,000 lines was cut-over at Belo Horizonte on May 31. This is the largest number of lines cut over at one time at a telephone exchange in Brazil, probably in the whole of Latin America.

Present at the opening ceremony were the Brazilian Foreign Minister, Sr. Magalhães Pinto, the Minister of Communications, Sr. Carlos Simas, and the Swedish Ambassador to Brazil, Count Gustaf Bonde.

■ New Telephone Exchanges in São Paulo

An ARF exchange for 6200 lines was opened in the Santana district of São Paulo on July 26. When installed to full capacity the exchange will accommodate 80,000 lines. The entire requirement for São Paulo–according to the present development plan–is 206,200 new lines.

Within the framework of this plan new telephone exchanges were opened in the Lapa district on August 2 and in the Penha district on August 16.

■ Other Major Orders

In very stiff competition with four Japanese and two Brazilian telephone companies, Ericsson do Brasil (EDB) was awarded a contract on June 28 for installation in the town of Belém of 20,000 ARF lines and a manual LD exchange, 20,000 telephones and 250 pay-station telephones. The value of this order amounts to some 20 million kronor.

During the month of June EDB also received an order for the town of Salvador in the State of Bahia for 8400 ARF lines to a value of some 13 million kronor.

In total the Bahia authorities count on an expenditure of some 300 million kronor for building up an efficient telephone network.

No less than 30,000 ARF lines were cut over at Belo Horizonte on May 31, 1968, the largest cut-over that has ever taken place in Brazil. From the left in the front row are seen the Brazilian Minister of Communications, Sr. Carlos Simas, the Mayor of Belo Horizonte, Sr. L.A. de Souza Lima, and Sr. Landry Sales from CTB (Companhia Telefônica Brasileira). In the rear row is Sr. J. A. Wiltgen from CONTEL (Conselho Nacional de Telecomunicações).

The President of Ericsson do Brasil (EDB), Mr. Gunnar Vikberg, held a reception at his home in celebration of the association of L M Ericsson with the Brazilian cable company Ficap. (From right) Sr. Alberto Lee, Chairman of the Board of Ficap, the Swedish Ambassador to Brazil, Count Gustaf Bonde, Mr. William Grey, President of the American copper corporation Anaconda (shareholder in Ficap), Mr. Yngve Åkesson, President of Sieverts Kabelverk AB, and Mr. Gunnar Vikberg, EDB.

Large New Order from Saudi Arabia

In 1964 L M Ericsson and a local contractor received an order for the delivery and installation of complete telephone plants in all the major cities of Saudi Arabia.

The new order, for 32 million kronor, covers equipment for the extension of the capacity of these plants and for automatic connection of trunk traffic between them.

L M Ericsson Acquires Shares in Brazilian Cable Works

The profitability of cable production for the heavily expanding Brazilian network was reinforced in July, when L M Ericsson acquired shares in the Brazilian cable company Ficap. The Group's participation amounts to 38 per cent. The remainder is owned by the American corporation Anaconda and by Brazilian interests.

Ficap has a turnover of some 40 million kronor per annum. The production, as earlier, will be based on local labour and, as far as L M Ericsson is concerned, relates solely to the Brazilian market.

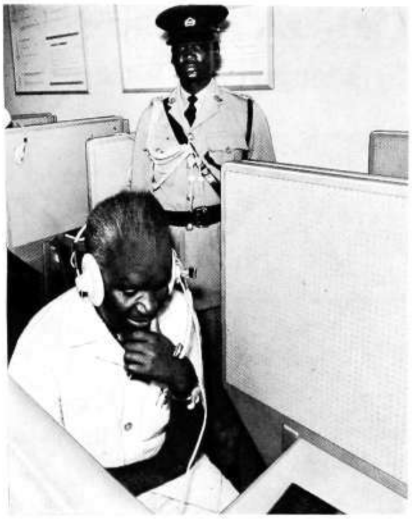
The new President of Ficap–which has its plant in a suburb of Rio de Janeiro—is Mr. Bo Gustafsson. He was earlier head of Quilmes, L M Ericsson's cable works in Buenos Aires.

Thailand Order for 8 Million Kronor

The Telephone Organization of Thailand (TOT) has ordered from L M Ericsson 10 trunk exchanges and a number of small local exchanges to a value of some 8 million kronor.

This equipment will permit the establishment of semi-automatic traffic between the larger Thailand cities. Under the terms of the contract the equipments supplied by L M Ericsson will be designed to permit the introduction of fully automatic traffic at a later stage.

Director-General Khoon Chamroon of Telephone Organization of Thailand (TOT) is here studying a gold coin which carries the image of the Thailand Queen Sirikit. The coin, which is highly coveted, was brought out in conjunction with the Queen's entry into her 6th century (one century = six years). Mr. Lars Edmark, of L M Ericsson, Midsommarkransen, made the presentation during a visit to Thailand to sign a contract with TOT worth some 8 million kronor.

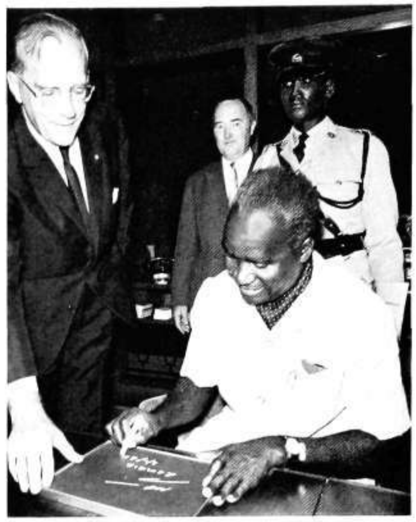


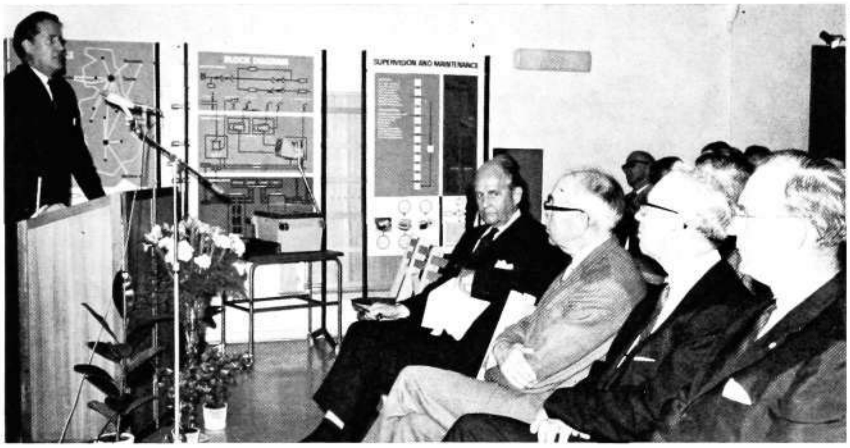
Dr. Kenneth Kaunda, President of Zambia, visited L M Ericsson in Midsommarkransen on July 3. He was accompanied by, among others, his ministers for foreign affairs, trade and agriculture.

During his visit the President expressed his appreciation of the company's work in Zambia and said that complete plans for the telecommunications of the country are to be drawn up. It is assumed that L M Ericsson will participate in the continued expansion of Zambia's telephone network.

In the photograph (left) President Kaunda is seen listening to a tape recording of "Swedish for foreigners" used in the language laboratory of the LME Training Centre.

The photograph on the right shows the President signing his name on a slate in accordance with the practice for heads of governments. Mr. Björn Lundvall, President of L M Ericsson, and Mr. Arne Stein, Head of Sales (behind the President), witness the ceremony.





◀ As appears from articles in this number of Ericsson Review the first stored program controlled exchange produced by L M Ericsson has been cut over at Tumba outside Stockholm.

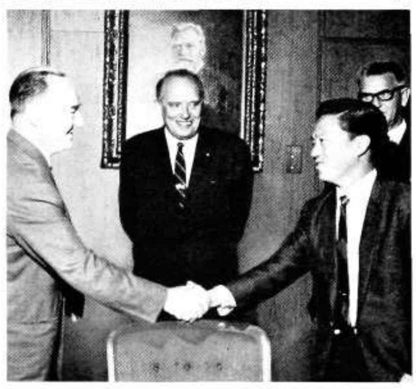
The visitors to the official opening on June 10 are seen being welcomed by Mr. Lennart Sjögren, Regional Manager of the Telecommunications Administrations. From left in front row: Mr. Bertil Bjurel, Director General of the Administration, his Danish and Icelandic colleagues, Mr. Gunnar Pedersen and Mr. Gunnlaugur Briem. Nearest the camera is Mr. Björn Lundvall, President of L M Ericsson.

In 1967 the statutes for an L M Ericsson scholarship award to an Irish engineer willing to make an academic career in telecommunications were handed over to the Irish Minister of Communications. ▶

The first holder of the award, Mr. Kevin B. O'Riordan, arrived at L M Ericsson in Midsommarkransen on September 2, where he was welcomed by, among others, Mr. Nils Kallerman. Mr. O'Riordan is seen trying out one of the Ericofons in the Exhibition Room.

Mr. O'Riordan is 24 years of age, an electromechanical engineer, and at present employed by the Aviation Section of the Irish Telecommunications Administration, where he is engaged in the fields of navigation and telecommunications.

The photograph below was taken in conjunction with the signing in September of a five-year contract with Singapore at L M Ericsson, Midsommarkransen. The Chairman of the Singapore Telephone Administration, Mr. Alan Yeo (right), and Mr. Arne Stein, L M Ericsson, shake hands in the presence of Mr. Malte Patricks (centre) and Mr. Hans Augustinson, both of L M Ericsson. ▼



◀ Representatives of the Russian Purchasing Organization, Mashpriborintorg, and L M Ericsson completed their negotiations during July at Midsommarkransen for technical cooperation and delivery of five large automatic trunk exchanges. Total value: over 65 million kronor.

(Left) The President of Mashpriborintorg, Mr. Nicolai Vasiliev, signs the documents in the presence of Mr. Jelena Aparina of the same organization, Mr. Juri Brezhnev, Commercial Counsellor, and Mr. Malte Patricks, L M Ericsson.

Mr. John A. Some, Deutsche Ericsson GmbH Telematerial, on the platform, notifies a press conference at Dusseldorf of the release of the Dialog and Ericofon telephone sets on the West German market.

L M Ericsson's Dialog and Ericofon Now on West German Market

L M Ericsson is the first foreign telephone enterprise to receive a licence to sell telephones on the West German market.

The sales company of the Group in West Germany, Deutsche Ericsson GmbH Telematerial, applied on October last year to the Deutsche Bundespost for a sales licence. After extensive negotiations the Dialog was released on March 1 and the Ericofon on April 5. The licence applies solely to telephones connected to private exchange systems. The size of the market is estimated at some 200,000 telephones.

In conjunction with this event a press conference was arranged at the Park Hotel, Düsseldorf, where the new telephones on the West German market were presented to representatives of the daily and trade press, radio and television. Positive comments were received from the press. A few headings: "New telephone fashion from Sweden", "Ericofon now on German desks", "Swedish telephone in nine colours".

Technical Cooperation AB Ermi – Landis & Gyr, Switzerland

L M Ericsson's subsidiary AB Ermi, Karlskrona, has recently concluded an agreement for technical cooperation with the Swiss firm Landis & Gyr. There is at present no question of cooperation, however, within the sales field.

Through the agreement the two companies will be able to divide their aggregate development costs over a larger volume of production. Ermi have therefore decided to manufacture on licence Landis and Gyr's double tariff meter instead of bringing out a meter of their own.

Ermi will also stock the Swiss firm's timing switch, and there are certain plans for cooperation also as regards the excess energy meter.

New Head of L M Ericsson, Colombia

Mr. Valdemar Henriksson

Mr. Valdemar Henriksson has been appointed president of L M Ericsson's sales company in Colombia, Compañía Ericsson Ltda.

Mr. Olaf Gustafson, who now retires on pension, has been head of the company since 1954.

Carl-Erik Lindeberg In Memoriam

Mr. Carl-Erik Lindeberg

Carl-Erik Lindeberg belonged to a group of L M Ericsson engineers who laid the foundations of the telephone market in Latin America, which now absorbs some 30 per cent of the Group's turnover.

After graduating from the Royal Institute of Technology in 1924 and spending some years with the parent company in Stockholm, Carl-Erik Lindeberg was posted to the Mexican Telephone Company in 1928 and became its president in 1931.

He had gained experience in Sweden of telecommunications engineering and production, to which he added in Mexico a knowledge of telephone operations which carried him to the position of head of our companies in Argentina. He worked there from 1935 to 1954, during which time he also became acquainted with sales questions.

When Carl-Erik Lindeberg returned to Sweden and Midsommarkransen in 1954, he was put in charge, within the Management Staff Department, of the administration of our foreign agencies.

His period in Stockholm was interrupted by a couple of years in Spain. His great knowledge and rich experience were of great value in reconstructing the organization there.

L M Ericsson has great reason for gratitude to Carl-Erik Lindeberg and his life's work, which to so great an extent was devoted to the interests and growth of the Group.

His colleagues both abroad and in Stockholm remember with a sense of loss his friendship and good advice. The announcement of his death came as a surprise on May 8. We would have wished him many years of enjoyment of his retirement.

Arne Stein

The Ericsson Group

Associated and co-operating enterprises and technical offices

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Centrum Electronic S. A. *F-75-Paris 17e*, 32, Rue Legendre, tel: (1) 267 30 10, tgm: centrumfrance

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Production Control (Ericsson) Ltd. *Morden*, Crown House, London Road, tel: (01) 542 1001, tgm: productrol, telex: 935979, "SWEDERIC LDN"

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A/S Industrikontroll *Oslo 6*, Grenseveien 86/88,3. etg., tel: (02) 68 72 00, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.O.B. 500, tel: (02) 83 76 50, tgm: kabel, telex: 6549, "KABEL D"

A/S Telesystemer *Oslo 6*, Tvetenveien 32, Bryn, tel: (02) 46 18 20, tgm: telesystemer, telex: 6900, "ALARM OSLO"

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Telefonaktiebolaget L M Ericsson, Technical Office, *Warszawa*, Ul Nowy Swiat 42, tel: 26 49 26, tgm: tellme

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Casa Konsult AB, *125 42 Älvsjö*, Huddingevägen 417—19, tel: 08/47 25 65, tgm: casakonsult

AB Ermi, *371 01 Karlskrona 1*, tel: 0455/230 10, tgm: ermibolag, telex: 4819, "ERMI KKR"

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L M Ericsson Data AB, *171 88 Solna*, tel: 08/83 07 00, tgm: ericdata, telex: 1093, "ERICDATA STH"

L M Ericsson Telemateriel AB, *135 01 Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00 tgm: ellem, telex: 1275, "1275 TELERGA S"

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Teleindustria, S.A. de C.V. *Mexico I, D.F.* apartado 1062, tel: (25) 46 46 40, tgm: ericsson, telex: 0177485, "ERICSSON MEX"

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• AUSTRALIA & OCEANIA •

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Comin Khmere S.A. *Phnom-Penh*, P.O.B. 625, tel: 23334, tgm: engineer

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Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 492, tel: 87031, tgm: alhamra

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Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat telex: 048, "BEHBEHANI KUWAIT"

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Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 231624, tgm: skefko

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TELEC Electronics & Machinery Ltd. *Karachi 3*, 415, Mahboob Chambers, Victoria Road, tel: (90) 52648, tgm: elco

Philippines

U.S.I. Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: PN 3550, "USIPHIL PN 3550"

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Ethiopia

Mosvold Company (Ethiopia) Ltd. *Addis Ababa*, P.O.B. 1371, tel: 14567, tgm: mosvold, telex: 21090 "MOS-FIRM ADDIS ABABA"

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Transcandia Ltd. Telecommunications Division *Nairobi, Kenya*, P.O.B. 5933, tel: 27103, tgm: transcanda

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Libya

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J. Martins Marques & Ca. Lda. *Lourenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

Sudan

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Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

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Ateliers Mécaniques du SAHEL, *Sousse*, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

• AMERICA •

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Garcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3445, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 21 79 40, tgm: nilspira

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General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwiks

Honduras

Quinchón Leon y Cia *Tegucigalpa*, Apartado 85, tel: 2-5171, tgm: quinchon

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 24077, tgm: morrispark

Netherlands Antilles

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Nicaragua

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Panama

Sonitel, S.A. *Panama*, R.P., Apartado 4349, tel: 5-3640, tgm: sonitel, telex: 134, "PA 134 SONITEL"

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S.A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

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Dada-Dada & Co. *San Salvador* Apartado 274, tel: 21 79 40, tgm: dada

Trinidad, W.I.

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• AUSTRALIA & OCEANIA •

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CONTENTS

On cover: Power plant with 48 V 630 A thyristor rectifier, rack with cell switch and 48 V 2400 A battery termination, and distribution racks.

LM Ericsson Power Supply Systems for Telecommunication Equipments

Å. LJUNGBLOM, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.311.41:621.395
LME 781 786

After lengthy development work L M Ericsson can offer new equipments for the central power supply of telephone plants. Compared with earlier equipment the changes are radical. Entirely new systems, both electrically and mechanically, have been developed.

This article describes L M Ericsson's various power supply systems with storage batteries. A brief account is given first of storage battery operation and of enclosed type lead cell batteries with positive tubular plates. The systems incorporate the new equipments. Particular note should be made of the new series converter system. The article also deals with equipments for automatic operating charge, automatic parallel operation of rectifiers, voltage control and overvoltage protection, signalling of alarm and other conditions, instrumentation, distribution, and finally the mechancial structure of the equipments.

The thyristor-controlled rectifiers and series converters will be described in detail in later articles.

Flexibility—a Main Principle

The development of new equipment for the central power supply of telecommunication plants has been directed particularly to equipments for telephone exchanges, the technique of which today places higher requirements on the power supply than before.

One of the goals in the design of the new equipments has been to attain the greatest possible flexibility, so that power supply plants can be built in different sizes and for different supply systems with standardized units. This permits the use of the equipments for all types of telecommunication plants, e.g. telephone exchanges, telex exchanges, PBX and transmission equipment. Power supply plants based on the new equipments can be built for amperages from a few up to several thousand amperes.

The uniform mechanical structure, furthermore, is an advantage for combined plants. A combined plant may contain equipments for several system voltages and for additional apparatus of different kinds. In this way a concentrated plant can be obtained, of attractive appearance.

The building of power supply plants in units which are easily handed electrically and mechanically offers advantages in manufacture, testing, stockkeeping, transport and installation. The procurement of spare parts and the replacement of units in operating equipment are also facilitated.

All systems for central power supply dealt with in this article relate to storage battery operation. It may therefore be advisable to say a few words on this subject.

Storage Battery Operation

Storage batteries are practically always used in power supply systems for telecommunication equipments in which high reliability and an uninterrupted DC supply are required. In the sequel the shorter word "battery" will be used, by which is always meant a secondary battery or storage battery. Modern systems make use of the full float principle, i.e. the battery or batteries are normally always fully charged and do not take part in the supply of energy to the telecommunication equipment except during brief peak loading conditions.

The function of the battery is, on failure of the mains, to provide the telephone equipment with the necessary energy without interuption and as long as the failure lasts, or until a standby unit has come into operation. Electronic equipment in telecommunication plant does not permit high transient voltages. The battery, which has a very low impedance, proves to be an economical and suitable aid for reducing these transients. The low impedance of the battery is also used for damping ripple voltages from rectifiers or other interfering apparatus, and in telephone plant for reducing crosstalk.

Normal Output Voltage of the Power Supply Plant

To maintain the battery fully charged at the same time as the telecommunication equipment receives the necessary current, the output voltage must be adapted according to battery type and to the number of cells in series. The lead cell battery, which is without comparison the most common type of battery, requires a voltage of 2.15–2.25 V per cell. The battery manufacturer usually prescribes a value between these limits, e.g. 2.22 V. This value should be maintained with an accuracy of ± 0.5 %–±1 % in order to guarantee the best operating conditions for the battery and so increase its length of life.

Lowest Output Voltage of the Power Supply Plant

The lowest output voltage is obtained under abnormal operating conditions such as mains failure or a fault in the charging equipment. This voltage is determined by the final voltage of the battery, i.e. with battery fully discharged, by the voltage drop between battery and power supply outlet, and by the additional voltage from series converters, if any.

Final Voltage of Battery

Compared with other economically conceivable batteries today, the lead cell battery has a high final voltage. A considerable voltage drop nevertheless takes place when the battery is discharged. This is specially noticeable when the discharge occurs in a short time at high currents. Final voltages down to 1.75 V per cell occur (fig. 1).

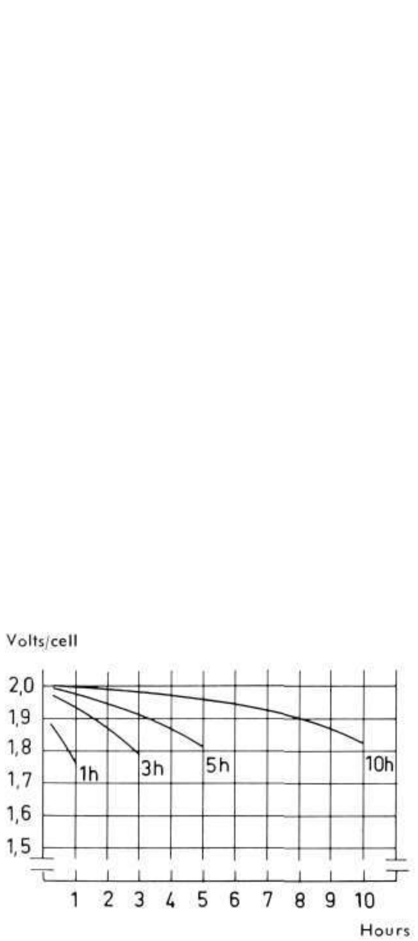


Fig. 1
The change of voltage in a lead cell with positive tubular plates on discharge during 1, 3, 5 and 10 hours

Highest Output Voltage of the Power Supply Plant

The highest output voltage occurs on charging of the battery or during a short time after filling with water, as the voltage must be raised to obtain circulation of the electrolyte by gassing in the battery. The maximum charging voltage for a lead cell battery is about 2.7 V per cell. During automatic charging, however, this voltage may be considerably lowered (min. 2.35 V per cell). This gives a longer charging time (see fig. 18) but can be allowed without great disadvantage. About 2.4 V per cell is required for circulation of the elecrolyte after filling with water.

Fig. 2

Enclosed type lead cell battery with positive tubular plates in two 6-cell group containers

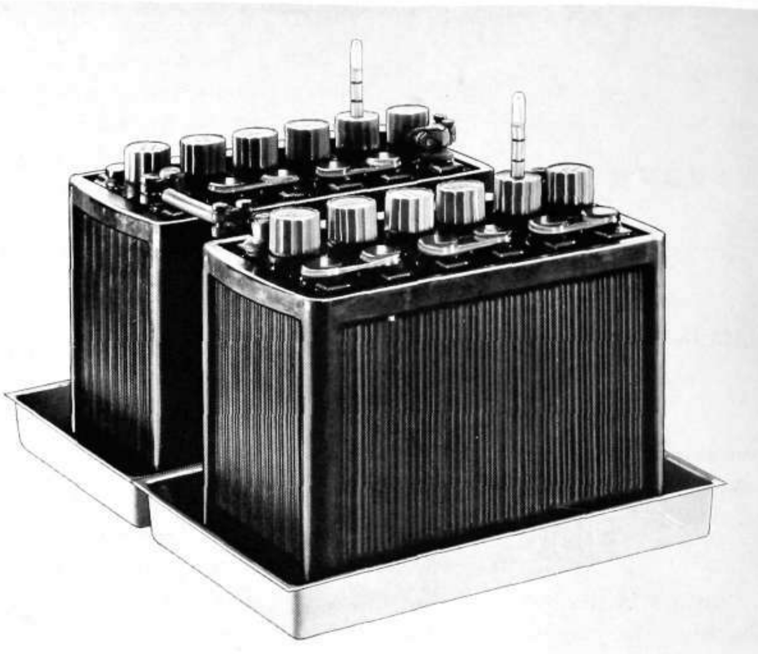
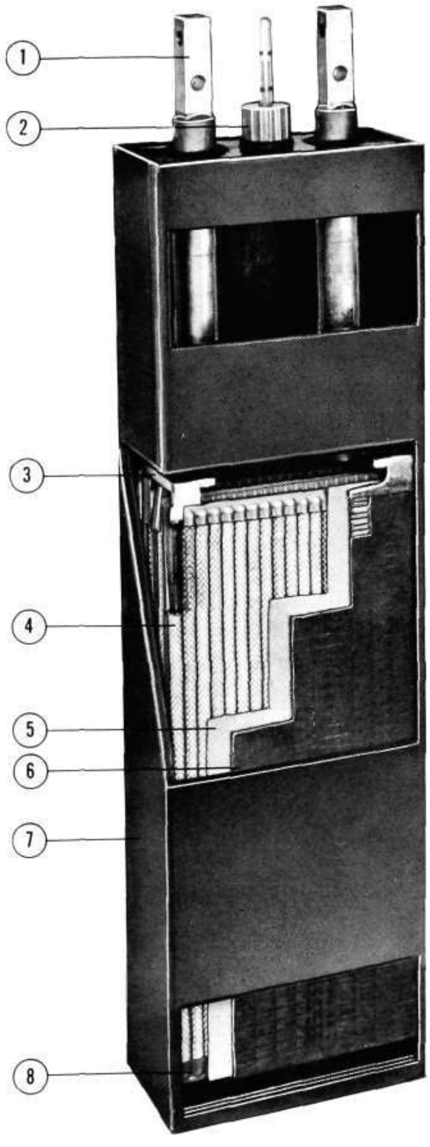


Fig. 3

Enclosed type lead cell with positive tubular plates

1 Post
2 Antispray vent plug
3 Plate strap
4 Positive plate
5 Separator
6 Negative plate
7 Cell container
8 Plastic tube sealer



Enclosed Type Lead Cell Batteries with Positive Tubular Plates

Stationary, enclosed type batteries with positive tubular plates were developed by the Swedish company AB Tubor in the early fifties in consultation with the Swedish Telecommunications Administration. Their manufacture has since been taken up by other battery producers both in Sweden and in many other countries. This type of battery has been used by L M Ericsson for telephone exchanges since 1955. The experience of their use has been very satisfactory. These batteries have many advantages and are also comparatively cheap.

The battery cells are usually delivered in dry charged or, whenever possible, in finally charged state. The charging procedure at the time of installation is hereby greatly simplified. Screw connections are used between the cells. This avoids the troublesome soldering work which was earlier necessary.

Compared with open type lead cell batteries of the Planté type the tubular plate batteries have considerably lower weight and volume for the corresponding capacity.

As a result of the design of the batteries the topping-up intervals have been considerably prolonged for batteries of single cell type. Some of the cells are furunished with level indicators with show the electrolyte level. The batteries have antispray vent plugs. A specially furnished battery room, which is necessary for open type batteries, is no longer required. The batteries are often placed in plastic trays directly on the floor and can very well be located with other eqiupemnt, e.g. the remaining power supply epuipment (fig. 15).

Fig. 2 shows a group container battery with 2 × 6 lead cells. Fig. 3 shows a cut-away single cell.

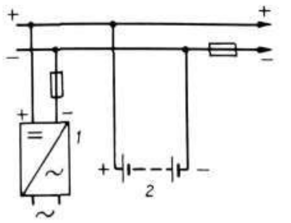


Fig. 4
Block schematic for ordinary full float system
1 Rectifier
2 Battery

Power Supply Systems Based on the New Equipments

The choice of system for the central power supply of telecommunications plant depends primarily on the voltage limits prescribed for the plant. Economic considerations are also important and lead to different solutions for different sizes of plant. The choice of system also depends on whether the plant is to be attended or unattended.

The systems for central power supply dealt with here are partly of conventional type and partly of a new type with series converter. All are applications of L M Ericsson's recently developed equipments for power supply. Each system will first be dealt with in its simplest form. Various additional equipments will then be described, each of which can be used or applied in any of the described systems.

Ordinary Full Float System

Schematic structure

By an *ordinary full float system* is meant a system with rectifiers and batteries which are always connected in parallel to the distribution. The system has no devices for lowering the distribution voltage during charging (counter-e.m.f. cells) or raising the voltage on discharge (series converters, cell switches).

Fig. 4 shows the system in its simplest form. A plant often consists of one or two rectifiers and battery. For this reason it is sometimes called a *single battery system*. Duplication of rectifiers may be desirable for increased reliability. In principle, moreover, the system permits parallel connection of any number of rectifiers and batteries. Parellel connection may be necessary for large plants from the outset or be required at a later stage when the plant is extended.

The system usually includes measuring instruments, equipments for issue of alarm, operating voltage supervision and automatic operating charge. These various equipments will be dealt with later in the article.

Applications

The condition for use of an ordinary full float system is that the telecommunications equipment permits the large voltage difference which parellel operation with one battery in this way involves. The voltage difference is the difference between the voltage requird during charging and the voltage during discharging.

Most plants for small telephone exchanges, fire alarm, electromagnetic locks, etc., which must operate also during mains failure, employ this system. The smallest plants usually have a special rectifier with facility for termination of battery and distribution. For rather larger plants the new power supply equipments are used which are dealt with in this article.

With the new equipments the system is used for small telephone exchanges. To obtain the normal operating voltage most appropriate for L M Ericsson's 48 V rural exchanges, 23-cell batteries are used. The highest voltage permitted by these exchanges during charging is 56 V. With 23 cells it is possible to charge the batteries also when the exchange is in operation, known as operating charge. Earlier, when there were 24-cell batteries, the charging took place when there was no traffic through the exchange. A signal to this effect was obtained from an X-contact. With 23 cells the charging of the batteries can take place as soon as the need arises, regardless of whether there is traffic through the exchange or not. This is further dealt with under "Automatic Operating Charge".

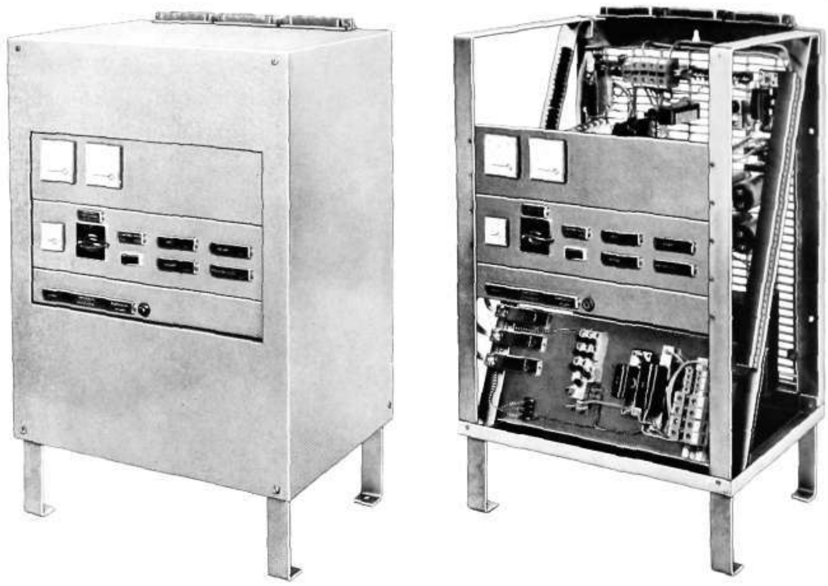


Fig. 5

Equipment for ordinary full float system with 16 A, 48 V thyristor-controlled rectifier, (Left) with, (right) without cover,

These types of exchange will not operate to a lower voltage than 44 V. With a 1 V voltage drop, therefore, the battery voltage during discharge must not be below 45 V. This corresponds to a final battery voltage of 1.96 V per cell. The battery capacity can then not be entirely utilized (see fig. 1). With long discharging periods, however, as are common with these types of exchange, it is cheaper to overdimension the batteries than to take other measures such as the introduction of cell switches or series converters.

For the power supply of L M Ericsson's new transmission equipments M4, very wide variations of the input voltage are permissible (see Ericsson Review 1/1967). In these cases a 48 V central power supply can suitably operate with 24 lead cells. This ordinary full float system can then be used with advantage also for large plants, and the battery capacity can be fully utilized.

Fig. 5 shows an equipment for an ordinary full float system. The equipment includes a 16 A 48 V thyristor-controlled rectifier with equipments for automatic operating charge, voltage supervision, and connection of battery and distribution.

Converter System

Schematic Structure

A *full float system with series converter* is a recent development. As appears from the name, it contains a converter. The system is therefore called, in brief, a *converter system.*

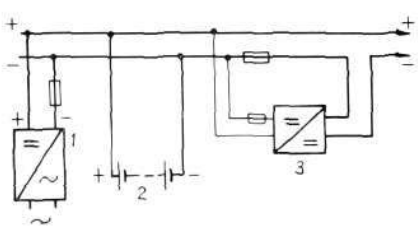


Fig.6

Block schematic for a small plant with converter system

1 Rectifier
2 Battery
3 Series converter

Fig. 6 shows a simple block schematic of the system. A block schematic with parallel-connected rectifiers, batteries and series converters is shown in fig. 7. The series converter is connected on the input side to the battery. The impressed voltage is converted to a DC voltage metallically separated from the input. The converter output with the low voltage is connected in series with the battery. In this way its output voltage is added to the battery voltage. The converters are entirely static and are started and stopped automatically.

The main units are: Rectifier (1) with operating unit (2) and mains contactor (3), battery (4), series converter (5), battery fuse unit (6) and distribution fuse unit (7).

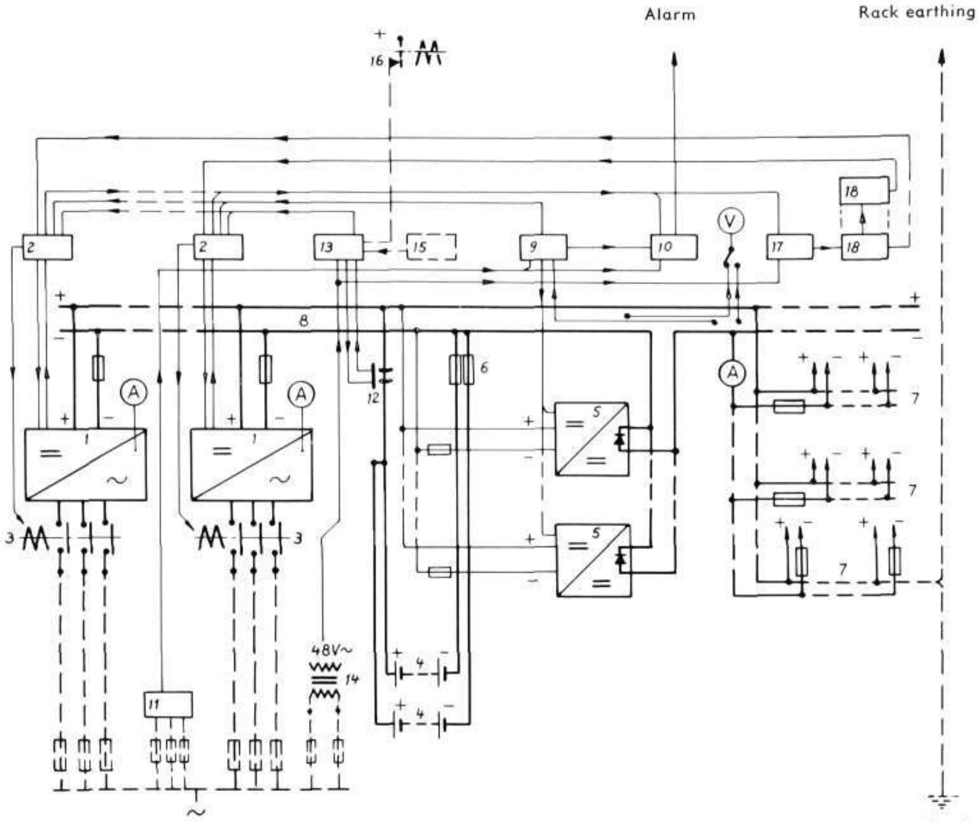


Fig. 7

Block schematic for automatic converter system with parallel-connected rectifiers. batteries and series converters

1 Rectifier
2 Operating unit for rectifier
3 Mains contactor for rectifier
4 Battery
5 Series converter
6 Battery fuse unit
7 Distribution fuse unit
8 Double pole interconnection
9 Voltage control unit
10 Alarm unit
11 Mains voltage control relay
12 Measuring transductor
13 Realy unit for automatic operating charge
14 Transformer for sec. 48 V AC
15 Timer
16 X-contact in telephone equipment
17 Limit relay with pulse generator
18 Stepping relay unit

A plant may comprise one of each of these main units. It may also initially, or at a later stage, consist of several of the units connected in parallel. The system permits extension of the equipment for the most varying requirements.

Apart from these units the equipment comprises a double pole interconnection (8) which, for low currents, consists of cables and, for higher currents, bus-bars. The equipment also includes measuring and supervisory equipment, usually comprising an ammeter, voltmeter, voltage control unit (9), alarm unit (10) and mains voltage control relay (11). Equipment for automatic operating charge is often included, comprising measuring transductor (12) with relay unit (13) and a small mains transformer (14) for secondary 48 V AC. Periodical battery tests can be made from a timer (15) or, if the telephone exchange has an X-contact (16), through the use of this contact.

In systems with several three-phase rectifiers the plant can be equipped for automatic parallel operation of the rectifiers. This equipment comprises a limit relay with pulse generator (17) and stepping relay unit (18). These are described under "Automatic Parallel Operation of Rectifiers".

Batteries and battery circuits are protected in different ways. In principle, rectifiers must not be connected to the distribution without being in parallel with at least one battery. In the systems in figs. 4 and 6 there are no actual battery fuses. This principle is employed for small plants. Fig. 7 shows the fusing arrangement in rather larger plants, when there are two or more batteries. If either of the fuses is removed or blows, the rectifiers are automatically disconnected. Fig. 8 shows the placing of the battery fuses for one or two batteries.

For different fusing arrangements see also figs. 16 and 17.

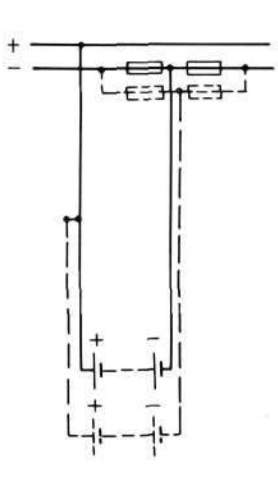


Fig. 8

Battery fuses for converter system with one or max. two batteries

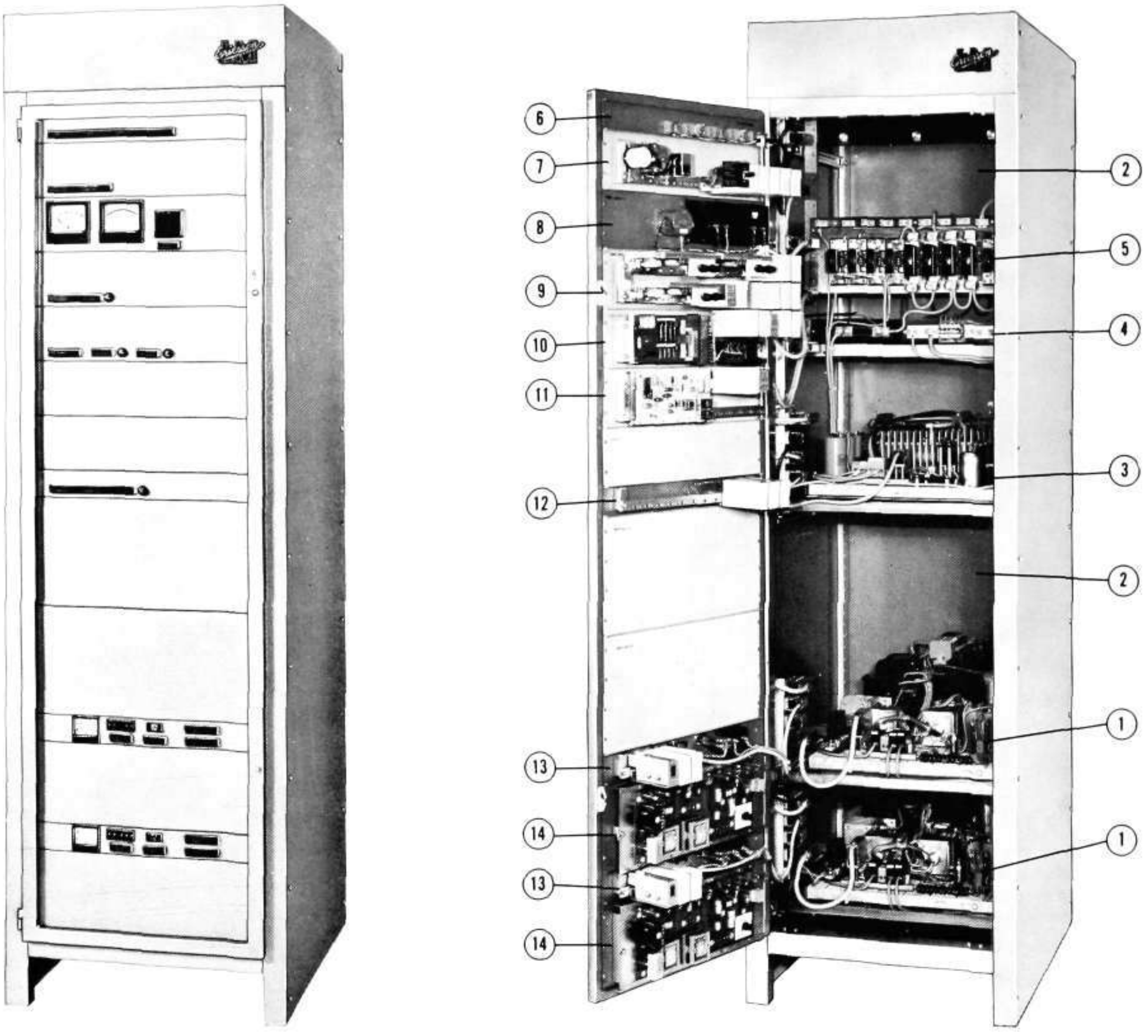


Fig. 9

Power supply equipment for 48 V with two 25 A thyristor-controlled rectifiers type BMT 234, a 40 A series converter type BMR 105 and fuse unit for batteries and distribution (Left) exerior and (right) interior

1 Thyristor-controlled rectifier
2 Space for additional equipment
3 Series converter
4 Shunt and measuring transductor
5 Fuse unit
6 Lamp unit
7 Alarm unit
8 Instrument unit
9 Voltage control unit
10 Relay unit for automatic operaiting charge
11 Oscillator for converter
12 Operating unit for converter
13 Operating unit for rectifier
14 Control unit for rectifier

Operation

Normally the system operates in the same way as an ordinary full float system. The rectifiers are adjusted for a normal operating voltage which maintains the batteries constantly fully charged.

On a drop in the voltage, usually owing to discharge as a result of mains failure, the series converters enter into operation. They add their output voltage to the battery voltage. In this way the batteries can have a relatively small number of cells which can nevertheless be utilized until completely discharged. The difference between the output voltage from the power supply system during charging and discharging can thus be reduced.

Starting and stopping of the series converters takes place automatically and is controlled by the voltage control unit (9). When the voltage has fallen to a preset value the series converters start. In the same way they are stopped when the voltage rises to another preset value.

The series converters are not voltage-regulated. For a 48 V system voltage the additional voltage is 5–7 V depending on the load.

Series converters with regulated output voltage have hitherto been designed in two sizes. Other sizes are being developed. The additional voltage is regulated according to the output voltage of the power supply equipment. The latter is kept constant irrespective of battery voltage and load. The additional voltage may vary from 0 to 8 V at 48 V system voltage.

Fig. 10

Power supply equipment for 48 V with two 400 A thyristor-controlled rectifiers type BMT 173, two 400 A series converters type BMR 110 and one 1200 A distribution rack type BMG 201

Characteristic Features

The regulating systems for the various units are entirely static, i.e. without moving parts. On the DC side, from battery and rectifier to distribution output, there are no moving contacts in the main circuit (compare cell switch system and system with different types of counter-e.m.f. cells).

The system allows all-automatic operation and can be used in unattended plants. The recharging of the batteries after a mains failure can be done fully automatically. The system can also incorporate equipment for continuous supervision of the state of charging of the batteries.

As already mentioned, the system permits utilization of the batteries down to a very low final voltage.

With regulated converters sudden changes of voltage are avoided. Very narrow requirements in respect of permissible voltage variation can also be satisfied.

As the system does not require a separate charging circuit, the battery switches and the switches on the output side of the rectifiers, as also the separate charging bus-bar, can be eliminated.

Compared with a cell switch system the converter system implies economies not only in the cell switch, but also in the extra cells and their charging equipment.

The system can be easily extended, which means that the initial installation need not be larger than is required for the immediate purpose.

Applications

Power supply equipments for converter systems have so far been delivered by L M Ericsson for several hundred telephone and transmission plants in sizes from roughly forty to several thousand amperes. Experience from the operation of these plants has been very satisfactory.

Lead cell batteries with 22 or 23 cells have been used for 48 V voltage systems. The lower number of cells is employed for batteries designed for long discharge times.

The lowest operating voltage for L M Ericsson 48 V telephone exchanges is 44 V. With a 1.5 V voltage drop in the power distribution, which is a usual value for large telephone exchanges, the lowest output voltage from the power supply plant would be 45.5 V. As the unregulated series converters add a minimum of 5 V, the battery voltage can fall to 40.5 V, which with 23 cells corresponds to a final voltage of 1.76 V per cell. Batteries with so short a discharge time as one hour can thus be utilized to 100 % capacity.

Figs. 9 and 10 show examples of equipments for a full float system with series converters. All examples include measuring and supervisory equipment, equipment for automatic operating charge and, in the plant in fig. 10, equipment for automatic parallel operation of the rectifiers.

Divided Battery System

Schematic Structure

A *full float system with separate charging* is a conventional system which has long been used for large telephone exchanges. This system is now known as a *divided battery system*. Other names are two-battery system or multibattery system. These names derive from the fact that the required battery capacity must be divided among at least two batteries. The system must also incorporate at least two rectifiers. Switches are required, furthermore, for all batteries and on the output side, on at least one of the rectifiers. The switches are double-pole two-way. They permit switching between distribution and charging circuit.

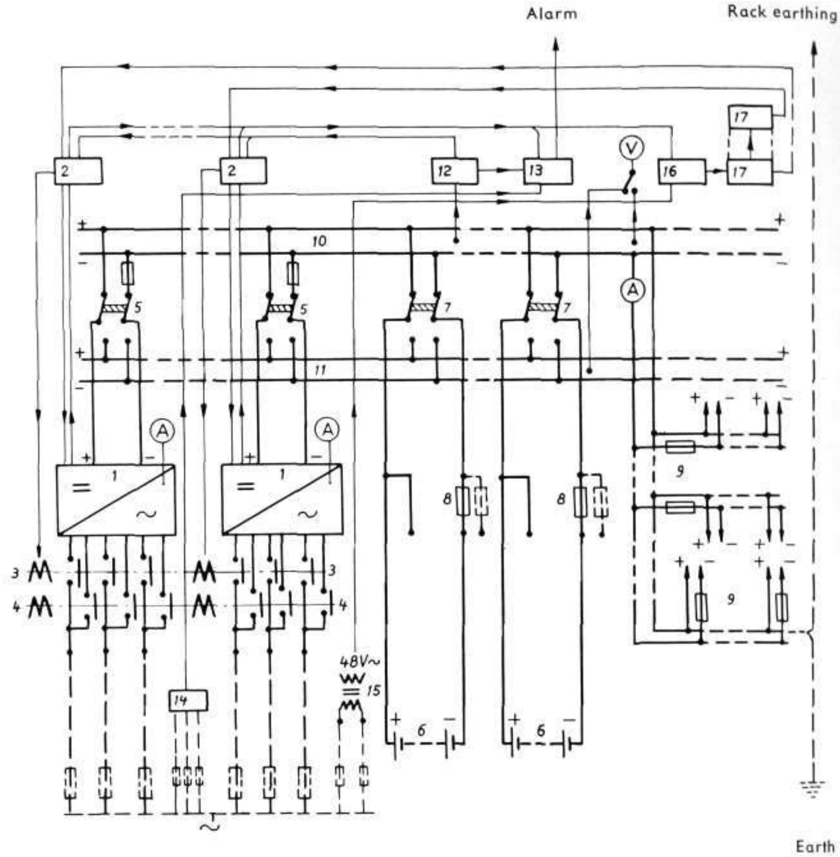


Fig. 11

Block schematic for divided battery system

1 Rectifier
2 Operating unit for rectifier
3 Mains contactor for normal operation
4 Mains contactor for separate charge
5 Output switch for rectifier
6 Battery
7 Battery switch
8 Set of battery fuses
9 Set of distribution fuses
10 Distribution bus-bars
11 Charging bus-bars
12 Voltage control unit
13 Alarm unit
14 Mains voltage control relay
15 Transformer for sec. 48 V AC
16 Limit relay with pulse generator
17 Stepping relay unit

For smaller plants a common switch for two batteries is used, arranged so that only one of the batteries can be disconnected from the distribution at one time. In larger plants, with one switch per battery, an interlocking device can be provided as extra equipment, so that the abovementioned conditions are fulfilled in these plants as well.

Fig. 11 shows a complete block schematic of the system containing measuring and supervisory equipment with voltmeter, ammeter, voltage control unit and alarm unit, and equipment for automatic parallel operation of the rectifiers.

With L M Ericsson's new power supply equipment the system may in principle consist of any number of parallel-connected rectifiers, batteries and distribution racks, either from the outset or after later extension.

Operation

Normally all rectifiers and batteries are connected to the distribution. The voltage on the rectifiers is so adjusted that the batteries are maintained fully charged. In order that the batteries may be used during discharge, the number of cells should be relatively high (24 lead cells for 48 V system voltage). This means that the normal operating voltage of the plant will often be close to the upper permissible normal operating voltage for the loading equipment.

Some telephone systems of other than L M Ericsson make do not permit so high a voltage as is required to maintain the batteries constantly under charge. Instead of reducing the number of cells or introducing counter-e.m.f. cells, cell switches or series converters, the normal operating voltage in these systems has been lowered.

If the voltage is lowered to about 2.08 V per lead cell, the batteries do not participate in the normal delivery of energy. Nor are they compensated for their selfdischarge. This means that the batteries must be regularly given a freshening charge.

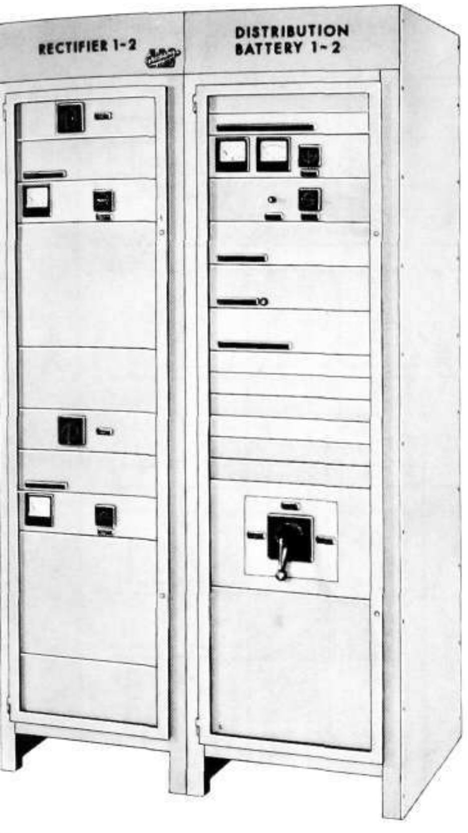


Fig. 12

Power supply equipment for 48 V with two 100 A thyristor-controlled rectifiers type BMT 143 and one 600 A distribution rack type BMG 203 with switch and fuses for batteries

After every mains failure or other circumstance causing discharge of the batteries, the batteries must be recharged. The procedure is that the number of rectifiers which are not needed for the distribution are connected to the separate charging circuit, but not more than are required for the particular battery capacity. To the separate charging circuit is then connected one battery at a time for charging. The rectifiers' charging current is set with a current limiting resistor. The rectifiers are initially constant-current-regulated. As the battery becomes charged, the voltage from the rectifiers increases. When the preset maximum voltage from the rectifiers has been reached, e. g. 2.7 V per cell, the rectifiers change to constant-voltage-regulation. Their current then diminishes as the charging continues until the battery is fully charged. This method implies that the batteries are charged by the quickest possible means.

Characteristic Features

The first cost of the equipment required by the system is often lower than the corresponding cost of a converter or cell switch system. Taking into account the cost of the batteries, however, this is not always the case. It depends on the size of the plant, the lowest permissible voltage during discharge of the batteries and the discharge time for which the batteries are designed.

The system is best adapted for medium-sized and large plants in which the ordinary full float system would necessitate too large and expensive batteries. The system requires the presence of skilled personnel at times when the batteries need to be charged. If there are automatic standby power units, however, such occasions are rare.

As already mentioned, the normal operating voltage will be close to the upper permissible limit for the loading equipment. On the other hand additional rises of the voltage to the loading equipment during charging are avoided, as the batteries are charged on a separate circuit. For certain equipments this may be a great advantage. The cell switch system described in the next section has the same advantage.

Applications

The divided battery system has been used ever since the introduction of the full float principle for battery power supplies. But with the growing requirements of lower normal operating voltage and automatic charging, the system has been increasingly replaced by systems with series converters or cell switches.

Fig. 12 shows a plant with modern power supply equipment using this system.

Cell Switch System

Schematic Structure

A *full float system with cell switch* is an extension of the divided battery principle. A shorter name is the *cell switch system*. As in the divided battery system, the rectifiers have double pole two-way switches on the output side. For the batteries in this system the switches are three-pole two-way. The cell switch system is intended for large plants, for which in certain cases it is cheaper than a converter system.

Fig. 13 shows a block schematic of the system. As in other systems rectifiers, batteries and distribution equipment can be connected in parallel and extended as required. The cell switch, however, which is common to all batteries, must be dimensioned from the outset for the final current.

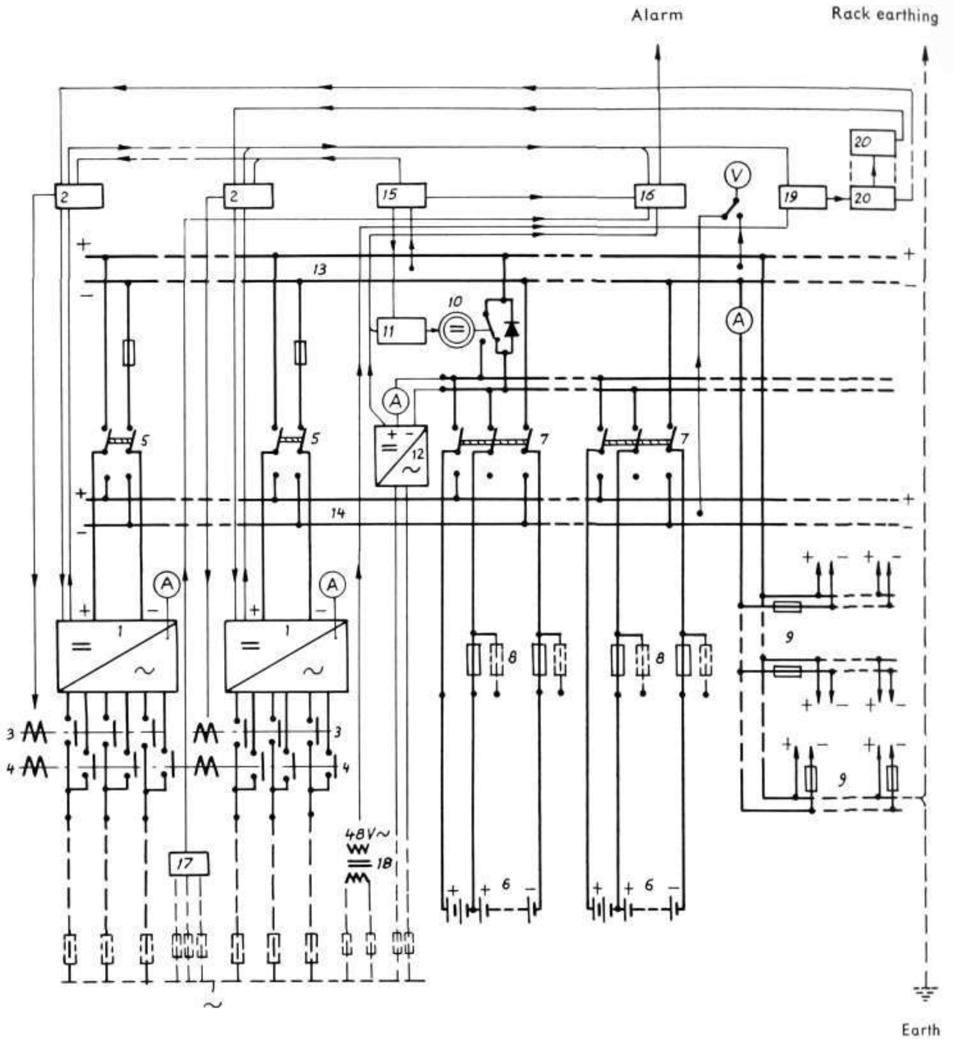


Fig. 13
Block schematic of cell switch system

1 Rectifier
2 Operating unit for rectifier
3 Mains contactor for normal operation
4 Mains contactor for separate charge
5 Rectifier output switch
6 Battery with extra cells
7 Battery switch
8 Battery fuse unit
9 Distribution fuse unit
10 Cell switch
11 Operating unit for cell switch
12 Rectifier for extra cells
13 Distribution bus-bars
14 Carging bus-bars
15 Voltage control unit
16 Alarm unit
17 Mains voltage control relay
18 Transformer for sec. 48 V AC
19 Limit relay with pulse generator
20 Stepping relay unit

The Cell Switch

L M Ericsson manufactures motor-driven reversible single-pole two-way cell switches in sizes up to 4800 A for system voltages of 24, 36, 48 and 60 V. These cell switches consist of a switch unit and a motor-driven operating device (fig. 14).

The switch unit is of the same type as the larger hand-operated switches for batteries. It has silver-plated contacts which are forced with high pressure against the silver-plated bus-bars. This provides a low-resistance contact. The switching involves no problems of arcing either for battery switches or cell switches, as the voltage difference on breaking is only a few volts. The switch unit, however, has spark-quenching devices as protection against faulty operation which would result in larger voltage differences.

The motor of the operating device is driven off the battery voltage. Levers for operation of the switch unit are actuated by a wormgear. On change of direction of rotation of the motor the cell switch returns to normal. The cell switch can also be operated by hand with a crank. In a window on the operating device is indicated the number of battery cells which the cell switch has connected to the distribution.

The cell switch also has a switch-over protection valve. This is a separate unit and consists of a number of parallel-connected silicon diodes mounted on a heat sink. The diodes are designed for continuous maximum current.

Compared with other cell switches, L M Ericsson's cell switch takes up very little space.

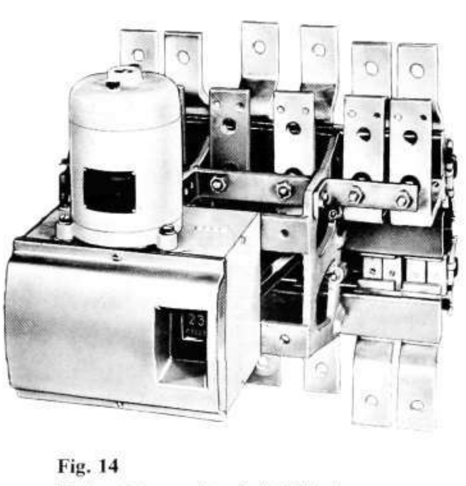


Fig. 14
Motor-driven cell switch 3600 A

Operation

In normal operation the cell switch is connected to the lower number of battery cells (fig. 13). These "main cells" are thus connected to the distribution in parallel with the rectifiers. The voltage of the rectifiers is so adjusted that these cells are maintained fully charged. The other cells of the batteries, the extra cells or end cells, are maintained fully charged by one or two small end-cell rectifiers. The main rectifiers deliver all necessary current to the load.

On a drop of voltage, usually due to discharge on mains failure, the cell switch automatically switches over to the higher number of cells. All cells of the batteries take part in the discharge. The discharge voltage is thus higher than if no extra cells were connected. During the switching instant the discharge current is conducted via the switch-over valve.

After av brief mains failure which has caused only a slight discharge of the batteries, the cell swich returns automatically to normal. This is of special advantage in plants with automatic standby power units. The latter usually deliver full voltage after only a few seconds. The primary current failure to the rectifiers is in such cases of very short duration. The entire plant is thus automatic and requires no manual action on or after mains failure.

After a mains failure of longer than 1/2 min (in the absence of automatic standby power units) the cell switch does not return to normal. The batteries have then been discharged and must be recharged. When the cell switch is positioned for the higher number of cells, the rectifiers are actuated so as to deliver a rather higher voltage than in normal operation. This higher voltage is adjusted to prevent further discharge of the batteries.

The manual charging of the batteries proceeds in the same way as described for the divided battery system. For charging of a battery its main cells and extra cells are connected to the charging circuit. The entire battery is thus charged by the main rectifiers which have been connected to the charging circuit. After all batteries have been charged, the cell switch is restored by pressing a button.

The automatic operation of the cell switch is controlled by the voltage control unit. The voltage limits for this operation are adjustable.

The end-cell rectifier is comparatively small and is usually used only for trickle charging of the extra cells, i.e. compensation of their self-discharge. It can be reset manually to deliver a higher current for an equalizing charge, if required, of the extra cells. The end-cell rectifier has an ammeter with two ranges, one for trickle charging and one for rapid charging current. If the normal trickle charging current is interrupted, an alarm is issued.

Characteristic Features

For very large plants the system may be cheaper than a converter system. Large plants are usually attended. Manual charging, in the absence of standby power units, is thus possible. Compared with a converter system, however, the possibly lower costs of this system in the initial stage must be taken into account; also that the automatic charging and the battery test, which can be arranged with a converter system, guarantee fully satisfactory battery operation without personnel skilled in battery maintenance.

As charging takes place on separate circuits, the high charging voltages to the distribution are avoided. This may be of advantage in certain cases.

Applications

For a 48 V system lead cell batteries are used, usually with 23 main cells plus 2 extra cells or, in some cases 22 + 3 cells or 23 + 3 cells. For a 24 V system the batteries usually have 11 + 2 cells.

Fig. 15 shows a plant with L M Ericsson's new power supply equipment using this system. See also illustration on cover.

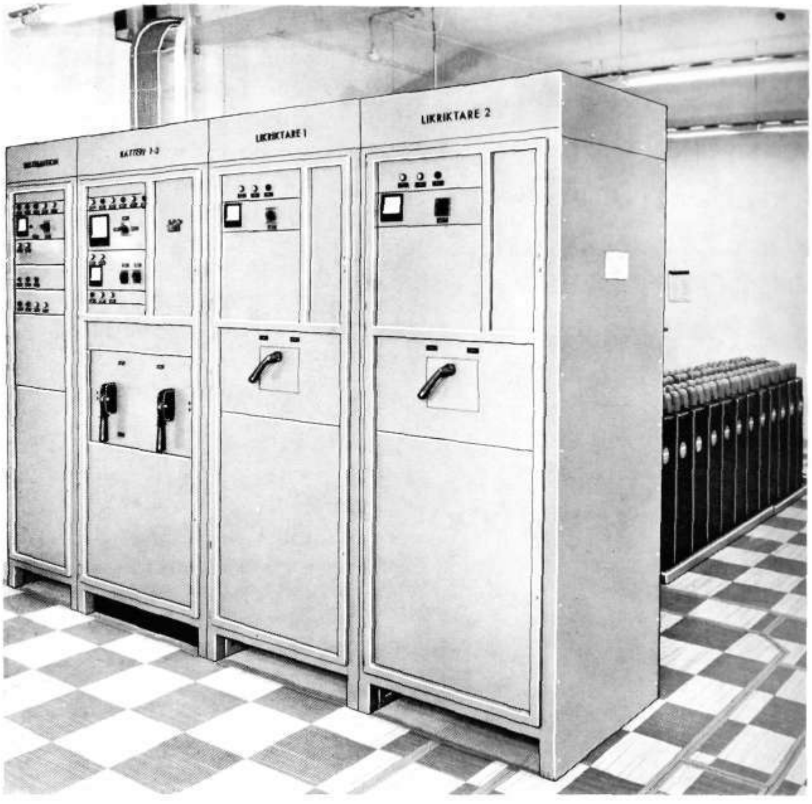


Fig. 15

Power supply equipment for 48 V with two 400 A thyristor-controlled rectifiers type BMT 173, a 1200 A battery and cell switch rack type BMG 401 and a 1200 A distribution rack type BMG 201

Power Supply System with Additional Voltages

Telephone exchanges sometimes contain equipment which requires a different DC voltage than the system voltage of the telephone exchange. Rectifiers without parallel-connected battery can be used if interruptions due to mains failure can be accepted.

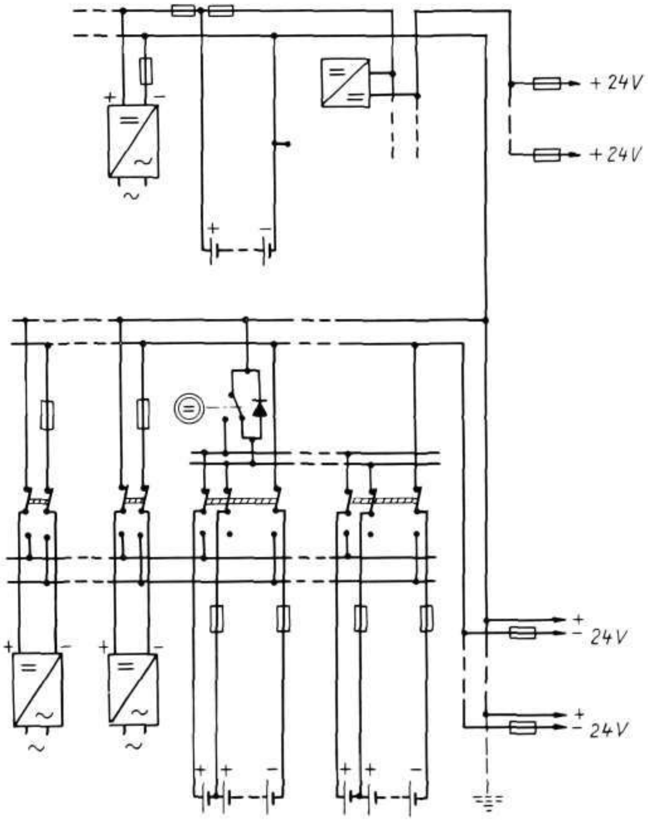


Fig. 16

Block schematic of power supply with additional voltage (24V+).

The example shows a combination of the cell switch and converter system.

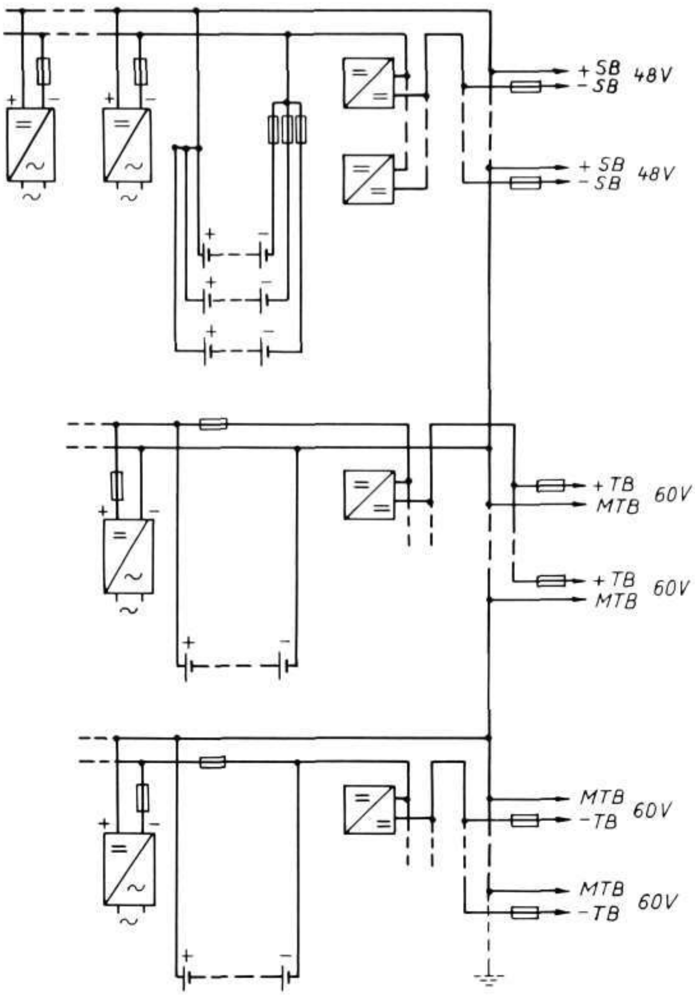


Fig. 17

Block schematic of power supply for telex exchange.
The example shows a combination of converter systems.

This is not usually the case. For small powers DC converters can be used which are fed from the central power supply equipment at the telephone exchange. For larger powers this is expensive. In such case a separate power supply equipment with batteries should be used. An example for 24 V telephone exchanges with 48 V microphone feed will be seen from the block schmatic in fig. 16. The plant consists of two 24 V installations in series. The main plant is in this example equipped with cell switch, while the plant for additional voltage has series converter.

Power Supply System for Telex Exchanges

In L M Ericsson's telex exchanges the system voltage for the switching equipment is 48 V. For telegraphy + 60 V and − 60 V are usually required. A block schematic of the various power supply plants with series converters for each is shown in fig. 17.

Automatic Operating Charge

It has been mentioned earlier that the charge which takes place when the loaded equipment is in circuit and operating is called operating charge. This charging can be done manually by resetting of the operating position switches on the respective rectifiers. The rectifiers then deliver their voltage at a preset operating charge level. From the curves in fig. 18 it will be seen that the charging time is longer the lower the voltage. A voltage lower than 2.3 V per lead cell results in so long a charging time that there is no guarantee that the batteries will reach full charge.

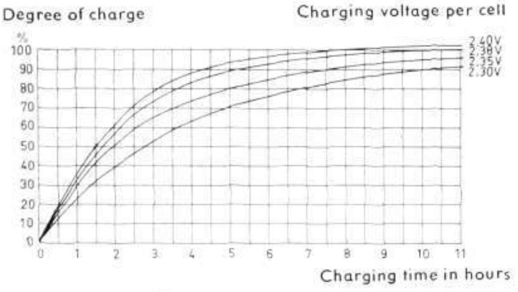


Fig. 18
Diagram of charging with constant voltage after 10 hours discharge of a stationary lead cell battery with positive tubular plates

All power supply systems described in this article can be equipped for automatic operating charge. The relatively long charging time is then of less importance. Consequently a very low operating charge voltage can be used. This results in the least possible consumption of water for the batteries, which is an important point in unattended plants.

In plants with rectifiers for 25 A or less, the equipment for automatic operating charge (measuring relay) is placed in the rectifiers. In plants with large rectifiers the equipment consists of units (measuring transductor and relay set) which are installed separately (figs. 7 and 9). The state of the batteries is tested by measurement of the charging current which they receive for a given cell voltage.

On mains failure, or if the loading current is greater than the total rated current of the rectifiers, the batteries are discharged. When the mains voltage returns or the loading current has fallen below the total rated current of the rectifiers, a charging current flows to the batteries which is greater than the normal float charging current. The equipment for automatic operating charge tests this current and issues a signal to the rectifiers so that they raise their voltage to operating charge level. In this way the batteries are charged. The charge continues until the current to the batteries has fallen to so low a level that the batteries may be considered practically fully charged. When the charging current has reached this low level, the equipment sends a new signal to the rectifiers, which are automatically reset to the normal operational level. This system has the great advantage that the charging of the batteries is started as soon as the mains voltage has returned or the loading current has fallen.

The equipment for automatic operating charge can be supplemented for regular checking of the state of charge of the batteries. By means of a test at operating charge level the state of the batteries is tested and, if required, automatic charging of the batteries takes place. The procedure is that a signal is issued to the rectifiers, e.g. from a timer, so that they raise their voltage to operating charge level. The rectifiers deliver an operating charge to the batteries until they are fully charged. They are reset to normal operational level in the same way as described in the preceding paragraph or by means of a timer, if desired. Telephone exchanges with X-contact, i.e. a contact which is broken when no traffic is passing through the exchange, can utilize this contact instead of the timer. This regular check guarantees that the batteries are always fully charged. In this way the normal operational voltage can be reduced, if desired, to a rather lower than normal value, e.g. from 2.23 to 2.20 V per cell, one advantage of which is the reduced consumption of water.

A battery test can also be made manually on the rectifiers or from another position, e.g. from an operator's desk or superior exchange.

For telephone exchanges which do not permit the high operating charge voltage during traffic, a signal from the X-contact can be used to block the operating charge so that it takes only when no traffic is passing through the exchange.

Automatic Parallel Operation of Rectifiers

L M Ericsson's power supply system may include equipment for automatic parallel operation of rectifiers. It can be used for all three-phase rectifiers and is employed for the power supply of large telephone exchanges or for other varying load with several rectifiers in parallel. The equipment determines how many rectifiers shall be in operation depending on the current requirement, and distributes the load to the individual rectifiers in a way which ensures the most rational operation. The equipment increases the total efficiency and life of the rectifier plant.

This equipment will be described in greater detail in a later article on thyristor-controlled rectifiers. It includes the following units (figs. 7, 11 and 13): limit relay with pulse generator and stepping relay units (one per rectifier). The operating unit for the rectifiers must also include a few extra relays. This unit is supplied in two types, with and without these relays. The limit relay requires a 48 V AC supply. This must be provided by a mains-connected transformer (which also serves the equipment for automatic operating charge).

Energy Saving

The equipment saves energy, as the rectifiers are connected to the mains as and when required. This avoids unnecessary idle losses. The same applies to standby rectifiers, if any, which are otherwise usually in circuit.

For calculation of the average energy saving at a telephone exchange with a power supply plant equipped for automatic parallel operation of rectifiers, the following assumtions are made:

n = number of regular rectifiers, of which one is always in circuit

P_L = rated power of the rectifiers

P_{max} = peak load

$$P_{max} = n \cdot P_L \qquad (1)$$

P_0 = idle losses per rectifier

$$P_0 = 0.02 \cdot P_L \qquad (2)$$

P_m = mean power requirement of a telephone exchange

$$P_m = 1/3\ P_{max} \text{ (at traffic concentration 1/8)} \qquad (3)$$

t = average working time in hours per day for regular rectifiers connected in sequence

W = energy consumption per 24 hours

$$W = P_m \cdot 24 = 1/3\ P_{max} \cdot 24 = 8 \cdot n \cdot P_L \qquad (4)$$

W_0 = energy saving per 24 hours = idle losses in $n-1$ rectifiers during $24-t$ hours of the day plus idle loss in one standby rectifier during the 24 hours.

$$W_0 = (n-1)P_0(24-t) + P_0 \cdot 24 = (n-1)\,0.02 \cdot P_L \cdot (24-t) + 0.02 \cdot P_L \cdot 24 \qquad (5)$$

Q = percentage energy saving

$$Q = \frac{W_0}{W} \cdot 100 = \frac{(n-1)\,0.02 \cdot P_L \cdot (24-t) + 0.02 \cdot P_L \cdot 24}{8 \cdot n \cdot P_L} \cdot 100 = \frac{(24-t)(n-1)+24}{4n}\ \% \qquad (6)$$

If $t = 6$ hours, $Q = 4.5 + \frac{1.5}{n}$, which gives the following energy saving for different numbers of regular rectifiers:

$n = 1$	$Q = 6.0\ \%$	$n = 2$	$Q = 5.3\ \%$	$n = 3$	$Q = 5.0\ \%$
$n = 4$	$Q = 4.9\ \%$	$n = 5$	$Q = 4.8\ \%$	$n = \infty$	$Q = 4.5\ \%$

Voltage Control and Overvoltage Protection

The power supply systems described include equipment for voltage control as a standard feature. This equipment consists of transistorized voltage-sensitive relays placed in a voltage control unit. For a system with converter or cell switch, voltage-sensitive relays for operation of these units are also placed in the same voltage control unit. At too high or too low a voltage an alarm is issued. Power supply equipment for L M Ericsson 48 V telephone exchanges also have voltage-sensitive relays for disconnection of the rectifiers. This takes place if the voltage is 58 V or above for longer than 10 seconds or attains 60 V.

Signalling of Alarms and Other Conditions

Different conditions (e.g. operating charge in progress) or faults (blown fuse or high voltage) in the power supply plant are indicated on lamps. For remote transmission of alarms all individual alarm signals from the power supply equipment are collected on one alarm unit. In smaller plants the corresponding signals are placed on the rectifier operating unit. According to the degree of urgency each fault can be signalled in one of the three categories (Alarms A1, A2 or A3).

Abnormal operating conditions can be signalled by an observation alarm or with one of the alarm signal categories. A condition of operating charge or mains failure can be signalled, for example, with observation alarm. The latter, however, requires a mains voltage control relay.

Instrumentation

Each rectifier has its own ammeter as standard feature. The power supply equipment also contains an ammeter for measuring the total distribution current, as well as a voltmeter with voltmeter switch, so that the distribution and charging voltages can be measured. In smaller plants the instruments can alternatively be replaced by test terminals.

Fig. 19
Fuse unit type NSF 213 with 10 glass cartridge fuses and transistorized alarm device

Distribution

Depending on the size of the plant the distribution outlet is designed in different ways. The smallest plants have only one outlet fuse common to battery and distribution (figs. 4 and 6). Large plants have a number of distribution fuses of different types.

The fuse unit *NFS 213* (fig. 19) accommodates 10 fuses of max. 6 A each. This unit contains a transistorized alarm device which delivers two separate positive signals if any of the 10 fuses has blown. A lamp on the unit also lights.

Fuse unit *BMF 202* (fig. 20) accommodates 9 fuse holders *NFS 512–513* designed for plug type fuses *NGG 502–503* for 6.3–100 A. An indication of a blown fuse is seen in the plug, and at the same time alarm contacts close. The cable connection is made with clamps on the fuse holder and on a busbar for the non-protected pole. Instead of these fuse holders a fuse unit *NSF 213* (see above) can be mounted in the corresponding position.

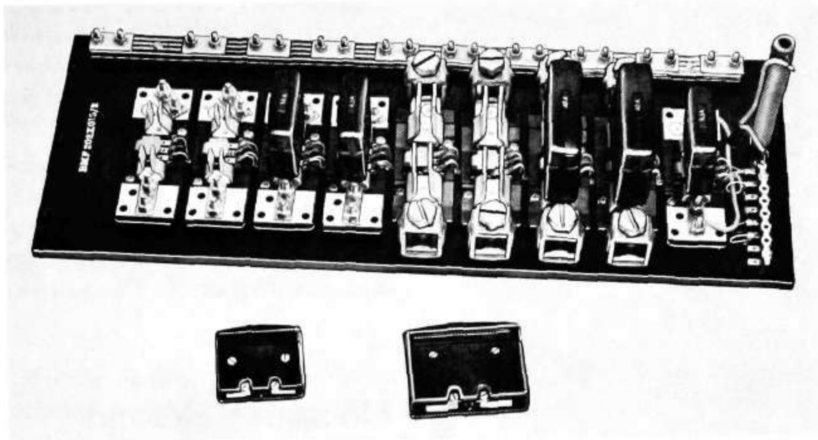


Fig. 20
Fuse unit type BMF 202

Fuse unit *694 100* (fig. 21) is designed for a standard grip fuse of power type in sizes 100–400 A for distribution racks, e.g. types *BMG 201–204*. The racks are made for different numbers of fuse units *BMF 202* or *694 100*.

Fuse unit *694 100* consists of a fuse holder (1) with grip fuse (2), alarm board (3) common to two fuses, output bus-bars (4) for + and −. The output bus-bars permit connection of six 150 mm² cables per pole. They are so arranged that + and − cables for each fuse lie pairwise.

The unit fits L M Ericsson's distribution system for larger exchanges. The connection is made with special cable clamps (5) type *NEY 932*. These clamps, in standard form, are made for 70 mm² and 150 mm² cable.

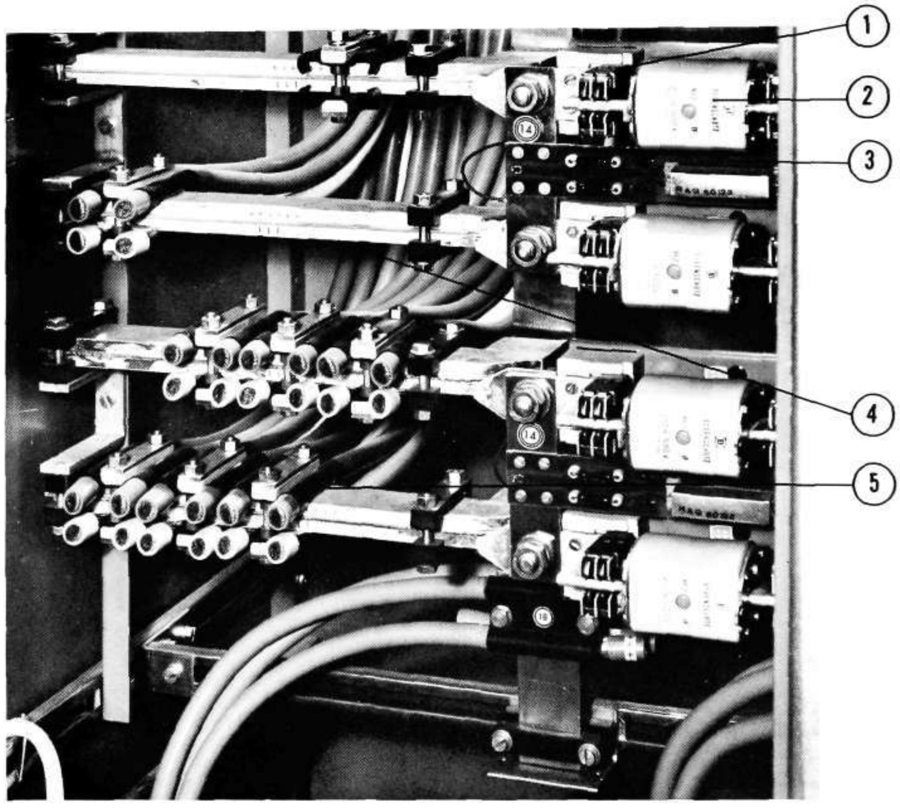


Fig. 21
Close-up of distribution rack with fuse unit 694100

1 Fuse holder
2 Grip fuse
3 Alarm board with reed relay
4 Output bus-bars for + and −
5 Clamp for 150 mm² cable

Cable clamp *NEY 932* was designed for connection of cables to bus-bars. The connection requires no special tools or holes in the bus-bar. Fully satisfactory contact between cable and bus-bar is guaranteed by the spring tension of the specially hardened clamps. No subsequent tightening is required.

The standard cables in the distribution system are sized 70 and 150 mm². When one cable per pole is insufficient owing to the voltage drop, several cables are connected in parallel. Parallel connection and mixing of + and − cables side by side ensures low impedance on the common battery-telephone equipment feed circuit. This contributes to low noise level.

Mechanical Structure

The mechanical structure of the power supply equipment described is based on a standardized modular system. Each item of equipment consists of one or more units. A large rectifier, for example, comprises several units, while a smaller may consist of a single unit.

For a large item of equipment, (e.g. rectifier 630 A 48 V) these units occupy an entire floor cabinet. Smaller items of similar or dissimilar type, on the other hand, can be placed in the same floor cabinet. For a small plant, accordingly, the complete power supply equipment, excluding batteries, can be accomodated in a single floor cabinet (fig. 9). Equipment of this kind may comprise rectifier, series converter, distribution equipment and supervisory equipment.

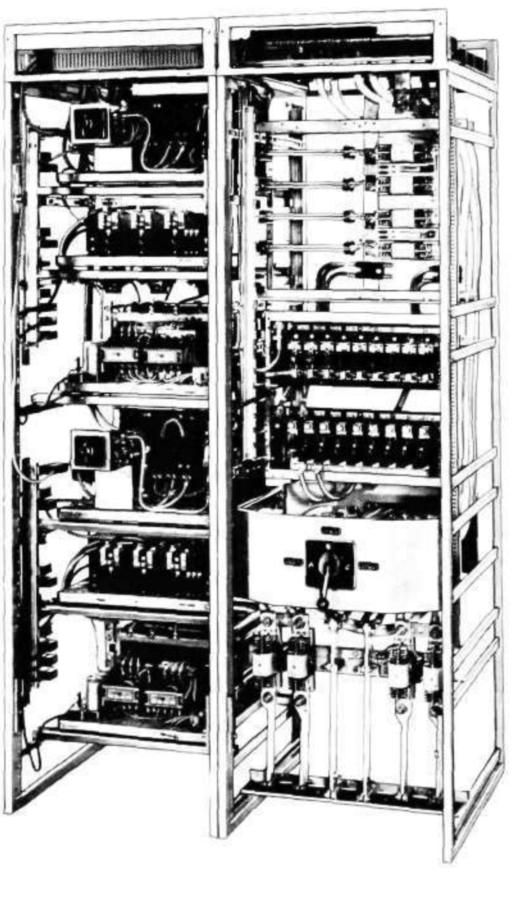


Fig. 22

Power supply equipment for 48 V with two 100 A thyristor-controlled rectifiers type BMT 143 and a 600 A distribution rack type BMG 203 with switch and fuses for batteries.

Doors and side plates removed.

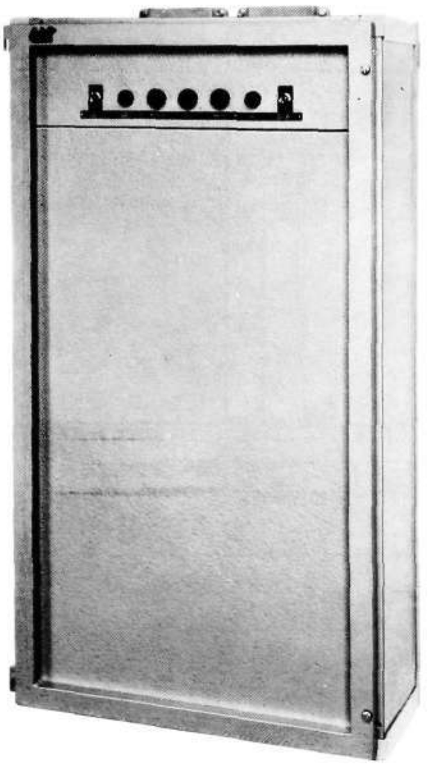


Fig. 23
Wall cabinet for power supply equipment

The floor cabinets are standardized and made in two basic types, one with height 2200 mm, depth 800 mm and width 600 (fig. 22) or 800 mm. For cell switch equipment there is also a 900 mm wide cabinet. At the top of the cabinets there is space for bus-bars. The other basic type of floor cabinet is 2040 mm high, 500 mm deep and 600 mm wide.

Apart from floor cabinets there are a number of wall cabinets of different heights and depths (fig. 23).

For the smaller single-phase thyristor-controlled rectifiers there is also an enclosure for wall mounting or alternatively with brackets for placing on the floor (fig. 5).

Units are constructed both for mounting in the door of the cabinet (door units) and inside the cabinet (cabinet units). Examples of door units are relay units, operating units, instrument units etc. Heavier units are made as cabinet units. Very heavy and bulky components, e. g. mains tranformers and filter chokes for 630 A thyristor-controlled rectifiers, constitute separate units and are placed inside the cabinets, as also are fuse units. Certain cabinet units are placed on steel gratings (grating units) (fig. 24). These provide ventilation even when mounted one above the other, as also does the deep floor cabinet. All grating units are placed horizontally in the deep floor cabinet and slide into the cabinet (figs. 9 and 22). Grating units for smaller rectifiers (smaller than 100 A 48 V) and converters (smaller than 100 A) have their heat sinks for diodes and thyristors so arranged that they can also be placed vertically. This is done in the narrow floor cabinet and wall cabinets.

The units are connected by plug and jack when small-diameter wire is used. Interconnections of units employing larger cable take place via easily accessible terminals. The interwiring of the floor cabinets is done in the same way. Bus-bars are placed stands at the top of the cabinets. Bending or drilling of holes in the bus-bars is usually not necessary. They need merely be cut to the correct length.

A plant is delivered in its various units. The floor cabinets are delivered dismantled and packed in a case. Each item of equipment is accompanied by one or more sets of fittings. Each set is individually packed. A set of fittings may consist of screws, cable clamps, interconnecting cables cut to the correct length, bus-bars etc. All components, units and terminations are clearly marked.

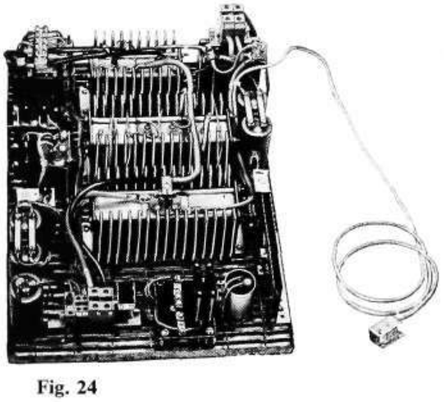


Fig. 24
Grating unit

This method of construction ensures a compact and easily accessible equipment. The floor cabinets can be placed against a wall (with the exception of cabinets containing cell switches). This saves the aisle which would otherwise be necessary behind the cabinets for servicing. Modern semiconductors have greatly contributed to reduced dimensions of the equipment. The 630 A, 48 V thyristor-controlled rectifiers of today, type *BMT 183*, have a 60 % smaller volume than the corresponding transductor-controlled rectifiers type *BMC 147*, and can also be placed against a wall. The space requirement for a modern power supply plant with enclosed type tubular plate batteries compared with corresponding equipment with transductor-controlled rectifiers and open type Planté batteries will be seen from fig. 25.

Fig. 25

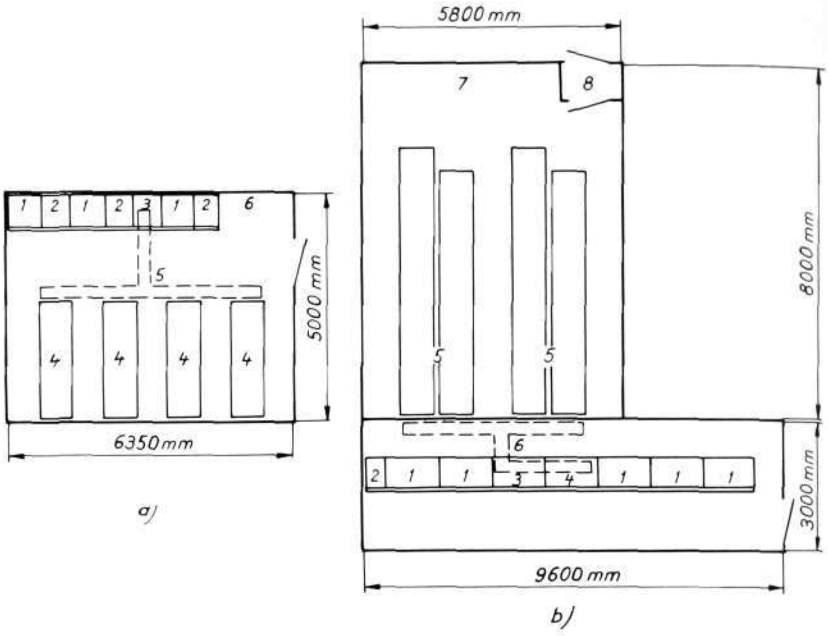
Sketch illustrating the difference in space requirement for a mordern and an earlier power supply plant (1200 A, 48 V) for a telephone exchange.

a)

1 Thyristor-controlled rectifier	630 A, 48 V
2 Series converter	630 A
3 Distribution rack	1200 A
4 Tubular plate battery with 23 cells	1608 Ah
5 Cable trench	
6 Space for work bench	
Total area	approx. 32 m²
Total battery weight	approx. 4000 kg
Weight of instrument panel	approx. 4300 kg

b)

1 Transductor-controlled rectifier	300 A, 48 V
2 Control panel	
3 Cell switch panel	2000 A
4 Battery and distribution panel	2000 A
5 Planté battery with 23 + 2 cells	2592 Ah
6 Cable trench	
7 Space for work bench	
8 Air lock	
Total area	approx. 75 m²
Total battery weight	approx. 14,000 kg
Weight of instrument panel	approx. 6500 kg



Other Power Supply Equipments

Other equipment as well is built on the principles described.

Examples are signalling units, of which a new, entirely static unit already exists in standard form. Static generators have long been used for ringing signals and tones. In the new unit the interruption of the signals and tones also takes place entirely statically.

The next item on the designer's programme is a complete series of regulated series converters. In the long run the semiconductor technique offers further possibilities within the field of DC converters with high intermediate frequency and pulse with regulation.

Summary

L M Ericsson's power supply systems are extremely flexible and can be adapted in a technically and economically advantageous manner to every individual requirement within the telecommunications field. Careful choice of components, ample safety margins, and the use preferably of static elements, ensure very reliable equipment which, used with modern batteries, requires a minimum of maintenance.

Fully automatic power systems can be supplied for unattended plant. The intervals between inspections can then be very long. L M Ericsson's power supply systems can normally be maintained by the personnel in charge of the telecmmunications equipment.

The power supply systems can be provided with facilities for rational supervision of the equipment. Transient voltages are effectively eliminated.

Plug and jack connection and the modular system facilitate both the initial installation and later extensions.

The space requirement is minimal. No special rooms are required. L M Ericsson's power supply equipments are designed for ambient temperatures up to 45°C and are not destroyed at temperatures up to 55°C. The total efficiency of the system is very high.

Line Concentrators

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UDC 621.395.73
LME 8362

It is important to utilize the existing lines in a telephone network as far as possible. With line concentrators the utilization of subscriber lines is four to five times greater than if each subscriber is allotted a line of his own.

L M Ericsson has developed two types of line concentrator: AKL 21 for max. 200 subscribers and ARL 21 for max. 20 subscribers.

A line concentrator consists of an exchange unit *MD* placed at the parent exchange and a subscriber unit *AD* installed in the vicinity of the subscribers. The two units are interconnected by a number of junction lines. In some cases separate pairs are required for signalling.

The chief use of the line concentrator is when a group of subscribers is concentrated to a point fairly remote from the nearest telephone exchange.

The most common cases in which these line concentrators can offer an economic solution are:

- when an ultimate capacity of 200 and 20 lines, respectively, should suffice for the foreseeable future and the line concentrator can be used as a permanent installation.
- when it is uneconomical to install an automatic exchange from the outset, with the high initial costs this involves, and the capacity of the line concentrator suffices for a fairly long period.
- when existing cables are practically fully utilized and it would be uneconomical for the time being, or undesirable on practical grounds, to lay new cables to serve a new group of subscribers.

The line concentrator can offer effective telephone service either as a permanent installation or until cables can be laid.

Line Concentrator AKL 21

General features

AKL 21 consists of an exchange unit *MD* placed at the parent exchange and a subscriber unit *AD* installed in the vicinity of the subscribers. The line concentrator is extendable in subunits of 50 lines and has a max. capacity of 200 lines. The subscriber unit need not be a 200-line unit but may be split up into several subunits connected to the same exchange unit. The subunits can be arranged in different ways depending on the number of subscribers and their geographical location. For each 50-line group the traffic is carried on ten 2-wire junctions, and three separate pairs are required per subscriber unit for signalling.

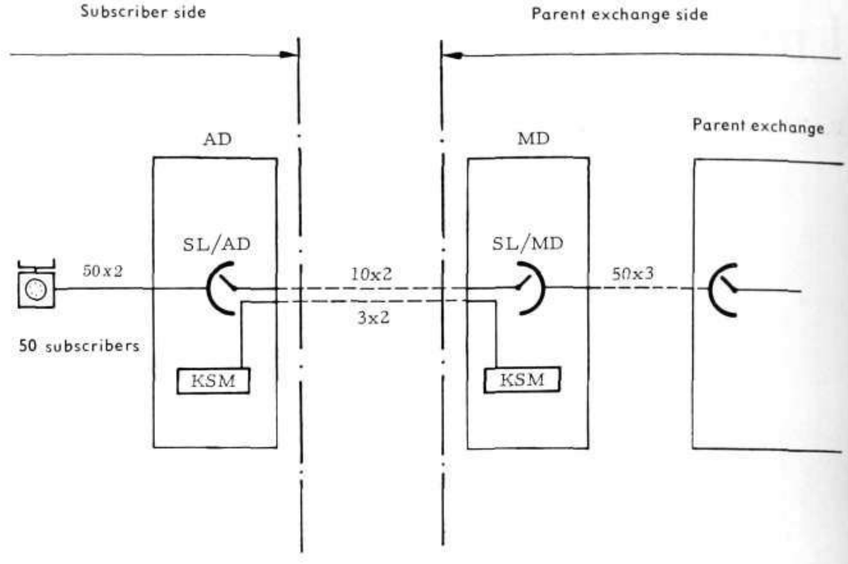

Fig. 1

AKL 21, trunking diagram

MD	Exchange unit
AD	Subscriber unit
SL/MD, AD	Subscriber stage
KSM	Code sender–receiver

AKL 21 will work with any system. It can be adapted to any type of parent exchange merely by replacement of a plug-in relay set. For a telephone administration this means that *AKL 21* is extremely convenient to stock even if there are different types of telephone systems in the country. If the line concentrator is moved from one type of parent exchange to another, only a relay set need be replaced.

Technique

AKL 21 is made up of L M Ericsson's code switches type *RVK*. This switch was selected since, in addition to its extremely good performance in general, it requires no current either in idle or working condition. Since the line concentrator should have a low total current consumption, this is a very valuable feature.

The communicating circuits are connected entirely metallically, and therefore no extra attenuation is caused by the line concentrator (see fig. 1).

On a call from an *AKL* subscriber the calling line is identified and its identity transmitted from a code sender in the subscriber unit *AD* on the signalling pairs to the exchange unit *MD*. *MD* selects a free junction line and returns the line identity to *AD*. The *AD* and *MD* switches are now set to the subscriber's position: in *AD* to his telephone line and in *MD* to his line circuit. The calling line is connected through to the line relay in the parent exchange. This relay operates and the setting up of the connection proceeds in the normal manner.

An incoming call is identified in *MD*. A free junction line is selected, and its identity together with that of the called line is sent to *AD*. In *AD* the switch connected to the selected junction is set to the subscriber's position. The same takes place in the exchange unit and the line is through-connected. Ringing signals are sent from the parent exchange.

AKL 21 has an equipment which, in the event of a fault on the signal wires, automatically shifts the signalling either to standby signalling pairs or to three of the junction lines. Return to the regular signalling pairs is ordered from the exchange unit.

On a fault on junction lines between *AD* and *MD* the faulty line is automatically blocked and an alarm is issued.

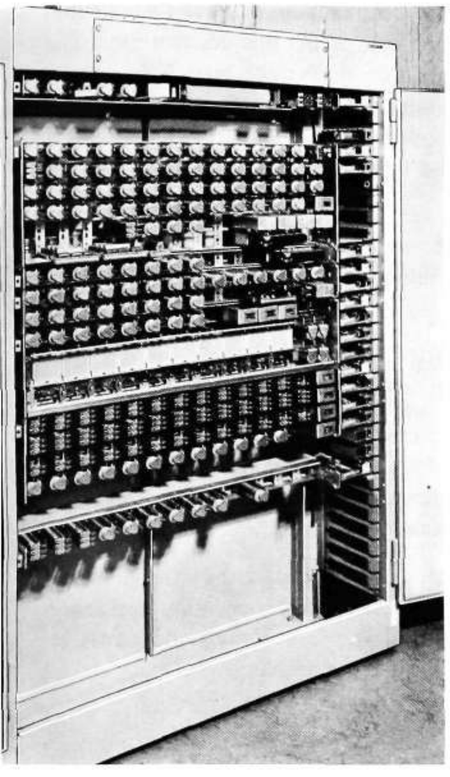

Fig. 2
AKL 21, subscriber unit

On a fault on the subscriber line as well, the line is automatically blocked. This is done either in *AD* or in *MD* depending on whether the line concentrator has equipment for individual line lock-out or not. In both cases an alarm is issued.

Recorders and counters for fault tracing and traffic measurements can be connected to *AKL 21*. For these purposes certain relays have been equipped with special contacts which are connected to separate test jacks in order to be readily accessible.

Alarms

Alarms are issued for different faults in *AKL 21*. From the subscriber unit an alarm is sent to the exchange unit in case of:

1. Blown fuse
2. Incomplete identification of outgoing call
3. Low battery voltage
4. Individual line lock-out

From the exchange unit one can determine which type of fault has arisen in the subscriber unit.

In the exchange unit alarms are issued for the following faults:

1. Blown fuse
2. Incomplete identification of incoming traffic
3. Loss of charging voltage
4. Junction line lock-out
5. Fault on signalling pairs
6. Failure of switch to restore

Mechanical Structure

The exchange unit *MD* and the subscriber unit *AD* are placed in light-grey enamelled steel cabinets sized respectively, 300 × 1050 × 2000 mm and 300 × 1050 × 1500 mm (figs. 2 and 3). The cabinets have locks and contain relay sets for plug-in connection. The rear of the cabinet has a cover and the front has two doors. In order to be placeable against a wall, the cabinets have wheels and a type of hinge which enables them to be swung out from the wall for inspection.

One *AKL 21* for 200 subscribers consists of four cabinets, two for *MD* and two for *AD*. One cabinet (in *MD* and *AD*) contains the common equipment and the first 50-line group, the other contains the three remaining 50-line groups.

Facilities

The numbering is entirely optional, which means that the *AKL* subscribers can be allotted any numbers available in the parent exchange.

If the parent exchange equipment includes individual line lock-out, this facility can be used by the line concentrator. In this way occupation of the junction lines is prevented, for example, when there is a fault on a subscriber's line or if a handset is not replaced or is left raised without the number being dialled. A special relay set also enables busy tone to be transmitted on a call to an *AKL* subscriber on line lock-out.

Busy tone can also be issued on a call to an *AKL* subscriber when all junction lines between exchange and subscriber units are engaged.

Fig. 3
AKL 21, exchange unit

The first ringing signal is sent from the parent exchange as soon as the connection has been completed to the exchange unit of the line concentrator. The time taken to switch the call through the line concentrator may fully or partially cover the period of this first signal, which will then not reach the called subscriber. *AKL 21* can therefore be equipped with a relay set which sends a renewed first ringing signal as soon as the line concentrator has put through the connection.

The maximum permissible line resistance between exchange unit and subscriber unit is 1300 ohms and between subscriber unit and subscriber (incl. telephone set) 1000 ohms.

The insulation resistance must not be less than 100 kohms for the subscribers' lines and 20 kohms for the junction lines.

The permissible line resistance between subscriber unit and subscriber (incl. telephone set) may, however, be increased to 1500 ohms by the introduction of a special relay set. This relay set also allows the permissible insulation resistance for subscribers' lines to be reduced to 20 kohms.

As the line is physically through-connected from the parent exchange to the telephone set, the total line resistance and permissible insulation resistance (junction line plus subscriber line) are naturally limited to the same values as for a subscriber line connected direct to the parent exchange.

Power Supply

Both the exchange unit *MD* and the subscriber unit *AD* are designed for 48 V supply.

The exchange unit operates to 48 V, which is normally obtained from the parent exchange. For connection to a 24 V or 36 V parent exchange the line concentrator has a separate 48 V battery and rectifier. For connection to 60 V exchanges a voltage limiter is used.

The subscriber unit is equipped with a 48 V, 10 Ah battery of *NIFE* type which is charged over free junctions. To compensate for the voltage drop on the junctions and to ensure a sufficient charging voltage, a rectifier delivering an auxiliary voltage of 12–24 V is required at the parent exchange. This rectifier is connected in series with the 48 V at the parent exchange, so that a total charging voltage of 60–72 V is obtained.

Traffic Measurements

As already mentioned, *AKL 21* has jacks to which counters for traffic measurement can be connected.

The following measurements can be made:

1. Number of incoming calls
2. Number of outgoing calls
3. Number of times switches are restored
4. Number of calls per subscriber's unit
5. Total number of calls encountering congestion on junction lines
6. Total number of calls per line concentrator.

Traffic Capacity

The total permissible outgoing and incoming traffic through *AKL 21* equipped with 50 subscribers' lines and 10 junction lines is listed below:

Loss in AKL 21	*Total traffic per subscriber*
0.2 %	0.072 erlang
0.5 %	0.083 erlang
1.0 %	0.10 erlang
5.0 %	0.14 erlang

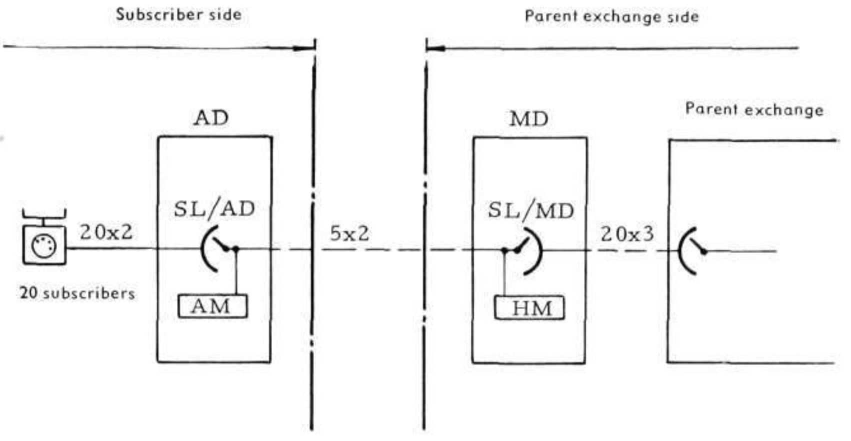

Fig. 4
ARL 21, trunking diagram
MD Exchange unit
AD Subscriber unit
SL/MD, AD Subscriber stage
AM, HM Code sender–receiver

Line Concentrator ARL 21

General features

ARL 21 consists of an exchange unit and subscriber unit and, like *AKL 21*, will work with any system since only a relay set need be replaced for matching to the parent exchange.

ARL 21 has a maximum capacity of 20 subscribers' lines and five junction lines between *MD* and *AD* (see fig. 4). No separate signalling pairs are required, as the signalling takes place on the junction line on which the conversation is later conducted. The switch is a crossbar switch with five verticals, one for each junction line. The subscriber unit is placed in a grey-enamelled steel cabinet measuring 200 × 425 × 1000 mm (fig. 5). The cabinet has a lock and is designed for wall mounting. Relays and switch are permanently installed and cabled. The cabinet is suspended on hinges and can therefore be swung out for inspection from the rear.

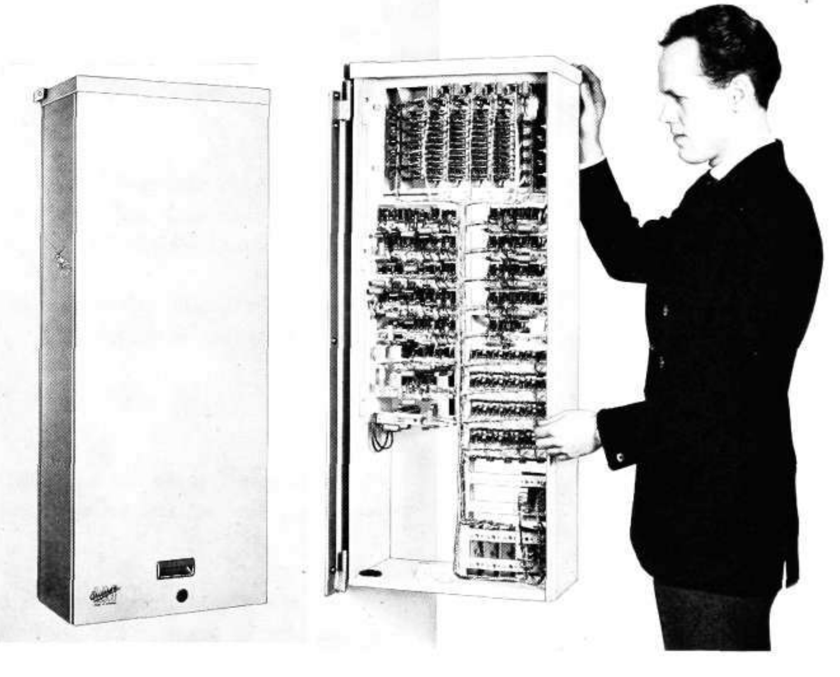

Fig. 5
ARL 21, subscriber unit. (Right) Swung out from wall

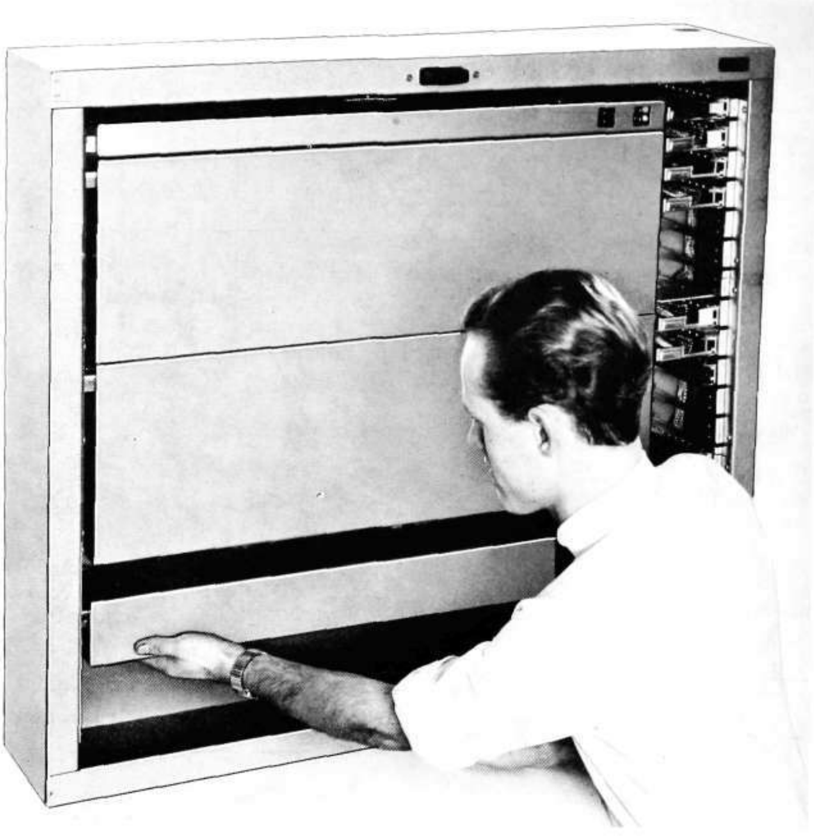

Fig. 6
ARL 21, exchange unit

The exchange unit consists of relay sets placed in a wall frame and connected by plug and jack. The dimensions of the wall frame are 220 × 870 × 1020 mm (fig. 6). The exchange units can also be placed in a floor rack accommodating four units.

Technique

The numbering is entirely optional, which means that subscribers can be given any numbers available within the parent exchange.

If the parent exchange has equipment for individual line lock-out, this facility can also be used by the line concentrator.

The lowest permissible insulation resistance is 15 kohms for the junction lines and 20 kohms for the subscribers' lines. For a junction and subscriber's line together, however, the insulation resistance must not be less than 10 kohms.

The maximum permissible line resistance is 1300 ohms for junction lines between *MD* and *AD* and 1000 ohms for lines between subscriber unit and subscriber (incl. telephone set).

It should be noted, however, that the permissible resistances of the parent exchange must not be exceeded.

Alarms

Alarm is issued from the subscriber unit to the exchange unit in case of a blown fuse, low battery voltage, and on incomplete identification of an outgoing call.

In the exchange unit an alarm is issued for a blown fuse, fault on junction line, and for incomplete identification of incoming traffic.

Power Supply

The exchange unit operates to 48 V, which is normally obtained from the parent exchange. For connection to a 24 V or 36 V parent exchange the line concentrator is equipped with separate 48 V battery and rectifier. For connection to a 60 V exchange a voltage limiter is used.

The subscriber unit is designed for 24 V and has a 10 Ah battery of *NIFE* type. This is charged over free junction lines from the parent exchange; setting of the required charging current is done in the subscriber unit.

Traffic Capacity

If the permissible extra loss for the line concentrator is 1 %, the total traffic will be 0.07 erlang per subscriber.

New Register Arrangement and New Three-Stage Group Selector for ARF 102

S. ELLSTAM, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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Registers and group selectors are two extremely vital switching elements in a modern crossbar system. As indicated in "L M Ericsson's Crossbar Systems, Their Development and New Traffic Facilities" in Ericsson Review No. 4, 1966, a new and improved register block has been developed and a three-stage group selector, specially adapted for large multi-exchange networks, has been designed. The new register arrangement and three-stage group selector are described in this article.

New Register Arrangement

The new register arrangement was developed in order to further increase the flexibility of the *ARF 102* crossbar system. It has already been introduced in several countries and will be standard equipment in future.

Besides increasing the traffic routing flexibility of *ARF 102* the new register arrangement also makes it easier to introduce new facilities such as push-button dialling and different principles of register signalling. Up to three separate signalling methods can be employed in the same exchange. This feature is of extremely great value and opens the way to future developments when in all probability even faster signalling methods than compelled sequence *MFC* signalling will be introduced.

Fig. 1 shows the structure of the new register arrangement. The functions of the various parts are described below.

REG-L consists, in standard form, of two relay sets I and II. The latter is used for receiving the dialled pulses and storing the called subscriber's number, while the former contains equipment for seizure och supervisory functions, storage of the class of service of the calling subscriber, and facility for termination of code receivers for push-button dialling.

Normally the register can itself determine the time for operation of the switches concerned. In complex networks, however, an analyser (*AN-REG*) is required which permits a more complete analysis.

Relay set II can be used unchanged for different purposes, while relay set I can be adapted to different requirements.
For identification of calling subscriber a relay set III is required for storage of the subscriber's number.

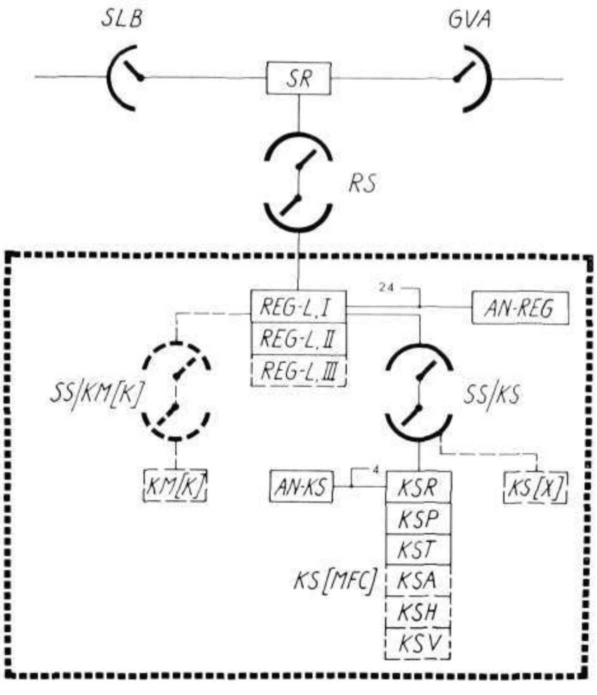


Fig. 1
The new register arrangement in system ARF 102

AN-REG is included in exchanges forming part of complex networks. Its function is to determine the time for operation of the switches, i.e. the number of digits after which *REG-L* must call *KS*.

One *AN-REG* can serve a maximum of 24 *REG-L*.

SS/KS is a sender-finder which connects *REG-L* to *KS* on a 20-pole basis. At the request of *KS*, furthermore, *SS* assists in switching over to one or at most two other code senders, e.g. *KS*[*X*].

KS [*MFC*] is a code sender consisting of three relay sets *KST*, *KSP* and *KSR*.

KST contains directional filters and channel receivers for control signals.

KSP consists essentially of chains for digit transmission (one position per digit) and control signal reception. *KSP* also contains equipment which permits the alternative use of L M Ericsson's normal type or of European type *MFC* signalling.

KSR handles interworking functions with *REG-L* and *AN-KS*, as well as functions for the restoring of *REG-L* and through-connection of the cord circuit *SR*, etc.

KST and *KSP* can be used unchanged for different purposes, while *KSR* can be adapted to different requirements.

AN-KS is an auxiliary device to *KS*[*MFC*] with the function of analysing the digits received and the class of service of the calling subscriber. The result of the analysis is notified to *KSR* which, among other things, uses it for selection of starting position in the digit transmission chain and for restoring of *REG-L* and through-connection of *SR*.

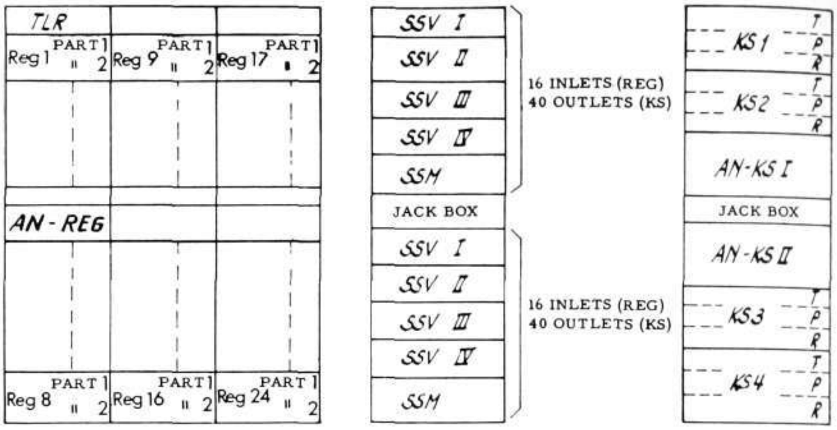


Fig. 2
The most common type of rack in the new register arrangement

Additional Facilities

The register described can be equipped with additional facilities as marked by the broken lines in fig. 1. A brief description of these facilities follows below.

Identification of A-Subscriber's Number

This facility is required, for example, in conjunction with toll ticketing on trunk calls. It is made possible through the fact that *REG-L* has a third relay set and the code sender an additional relay set *KSA*.

REG-L III contains a store for the *A*-subscriber's number obtained from the marker *SLM* in the finder–final selector stage, whereas *KSA* contains equipment for transmission of the *A*-subscriber's number.

Push-Button Dialling

Subscribers with push-button telephones can be connected to the *SL* stage by connection of a keyed pulse code receiver, *KM*[*K*], on a 10-pole basis to *REG-L* via *SS*/*KM*[*K*].

Different Methods of Digit Transmission

For switch-over to another method of transmission, e.g. from *KS*[*MFC*] to *KS*[*X*], *KSH* is connected to *KS*[*MFC*] (see fig. 1).

ARF 102 Terminal Exchange without Group Selector

An auxiliary equipment to *KS*, named *KSV*, is used for terminal exchanges *ARF 102* without group selector for setting up a connection through the *SL* stage to the desired route.

Rack Layout

Fig. 2 shows the rack layout and the normally used switching elements in the new register arrangement.

Of each group of three racks for altogether four registers only the first group contains pulse relays *TLR* and analyser *AN-REG*. A sender-finder *SS*/*KS* for 16 inlets and 40 outlets requires a half rack and contains one *SSM* and four *SSV*.

Four code senders *KS* containing *KST, KSP* and *KSR* with associated analysers *AN-KS* can be accommodated on one rack.

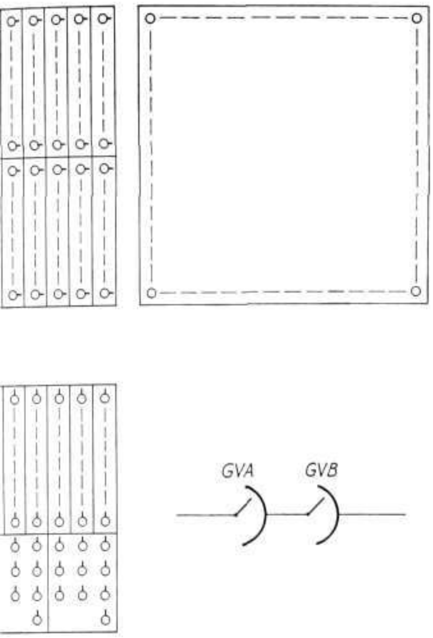


Fig. 3
Grouping plan for a group selector unit GV

Three-Stage Group Selector (GV Type II)

The usual two-stage group selector for *ARF 102*, *GV* type I, has 400 outlets, offers three alternative routes and has full facilities for analysis of 2 digits and partial analysis of a third digit. This group selector is suited as second group selector II-*GV*, combined second and incoming group selector II-*GV*/*GIV*, and as special group selector *GVS*. In small and medium-sized networks it can also be used as I-*GV*.

In large multi-exchange networks higher requirements are placed on I-*GV* in order that the best possible use of the junction line network may be ensured. For this reason a three-stage group selector, *GV* type II, has been developed. When installed to full capacity this group selector has 1600 outlets, offers five alternative routes and has full facilities for analysis of three digits and partial analysis of a fourth digit.

Group selectors types I and II have the same signal configuration outwards and can therefore interwork without any complication in a switching chain both within the home exchange and between different exchanges.

Fig. 3 shows a grouping with 80 *GVA* verticals (8 crossbar switches) and 120 *GVB* verticals (12 crossbar switches) which provide 80 inlets and 400 outlets. This – the final grouping for group selector type I – is the basic grouping for the *A* and *B* stages in group selector type II.

The multiple capacity of this group selector can be extended in accordance with the principles indicated in fig. 4. Initially the selector may comprise only two partial stages I-*GVA* and I-*GVB* (fully drawn lines in the figure) with 80 inlets and 400 outlets. Two such units are paired together to produce 160 inlets and 400 outlets. The introduction of a *C* stage is done on the following principles. Every stage has 100 inlets and 400 outlets and at most four separate *C* stages can be introduced. The multiple capacity is then increased from 400 stepwise to 700, 1000, 1300 and 1600. Two 80-line groups are connected, on the outlet side, in parallel with a *C* stage with 100 inlets.

The *C* stage is controlled by a marker which is permanently connected to the markers of the *A* and *B* stages. Conditional selection is employed for switching through all three stages.

The availability per route may vary between 5, 10, 15, 20, 40 and 80, and the maximum number of routes may be 180.

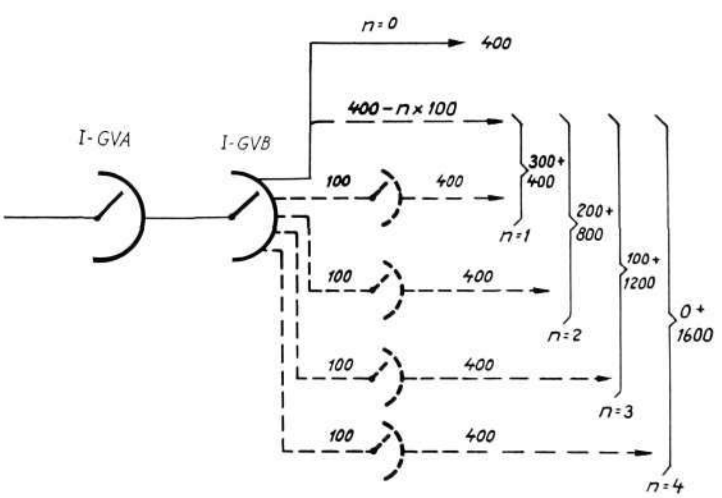


Fig. 4
Alternative phases of expansion in the new 3-stage group selector arrangement

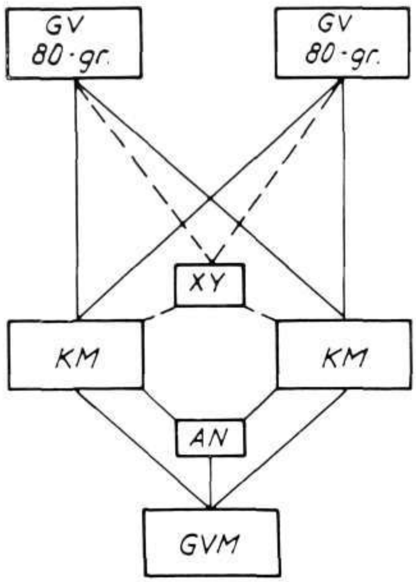


Fig. 5
The marker equipment in a group selector of type II

The marker arrangement for the *A* and *B* stages will be seen from fig. 5. For every 80-line group there is a code receiver *KM*, but code receivers for two 80-line groups may serve the two groups alternatively as shown in the figure. This improves the utilization of the code receivers.

The identifier *XY* and analyser *AN* serve two 80-line groups. The same applies to the group selector marker *GVM*.

The group selector is made in two mechanically differing models. In model *A* intermediate distribution is required, but can be eliminated in model *B*.

To permit the elimination of intermediate distribution, model *B* contains a larger number of jack units than model *A*.

The *C* racks in model *A*, moreover, are of type *BDD* with permanently cabled switches designed for single-sided mounting, whereas in model *B* the *C* switches are connected by plug and jack to *BDH* racks, so permitting double-sided mounting.

The rack layout for a group selector type II, model *A*, with 160 inlets and up to 1600 outlets and with associated marker equipment will be seen from fig. 6.

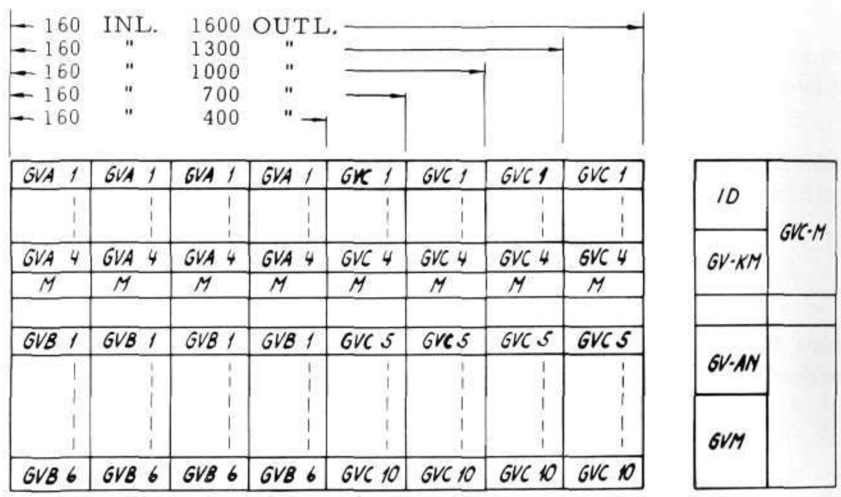


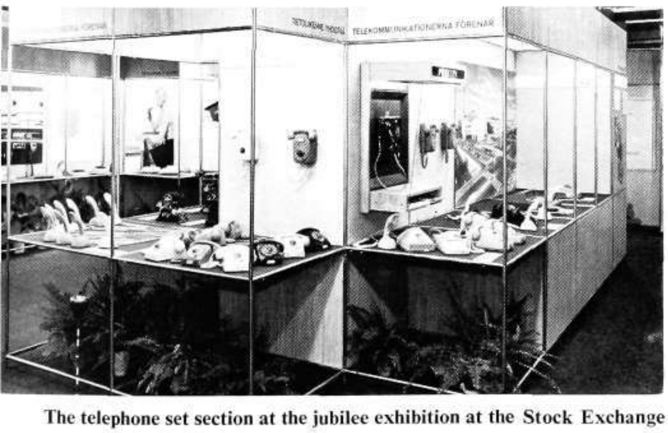
Fig. 6
Racks for a 3-stage group selector unit and associated equipment

ERICSSON News from All Quarters of the World

President Urho Kekkonen (right) studies the carrier equipment at the jubilee exhibition in the company of (from left) the President of LMF, Mr. Ingmar Horelli, the Minister of Commerce, Mr. Grels Teir, and Mr. Åke Piltz, LMF.

L M Ericsson's 50th Anniversary in Finland

President Urho Kekkonen (right) receives the jubilee gift, a specially manufactured Ericofon with the President's family arms, from Dr. Marcus Wallenberg.



The telephone set section at the jubilee exhibition at the Stock Exchange

On 28 November 50 years had passed since the pioneer of Finnish telephony, Daniel Johannes Wadén reformed his "electrical" business into L M Ericsson's subsidiary in Finland under the name O/Y L M Ericsson AB (LMF).

Daniel Wadén had for some decades manufactured and sold his own telephone sets and switchboards and had been chief salesmen for L M Ericsson in Finland.

LMF soon became the most important telephone supplier in Finland, as it still is today. The company has delivered equipment for almost all of Finland's trunk centres and the greater portion of the manual and automatic telephone exchanges in the country.

Finland is among the most highly developed telephone countries in the world and has today more than 1 million telephone sets in operation. In terms of telephone density Finland is ahead of such industrial countries as W. Germany, France, Italy and Japan. One hundred per cent automatization is in view in the next few years.

In 1934 the management of the company was taken over by Mr. Sven Weber. During his 25 years with the company LMF moved to its present building at Fabiansgatan, Helsinki, the manufacture of telephones and telephone equipment started in Finland, and a new factory was built at Drumsö. The expansion has since continued under the leadership of Mr. Ingmar Horelli. One example is the decision recently made to build a new factory at Kyrkslätt some 12 miles outside Helsinki. The intention is to transfer the entire enterprise there within the next few years.

The celebration of the 50th anniversary of the Ericsson Group in Finland took place in Helsinki on November 22 and was concentrated to a jubilee exhibition at the Stock Exchange and, in the evening, a dinner at the Fiskartorpet Restaurant. An extremely representative gathering was present, with the Finnish President, Urho Kekkonen, in the seat of honour. The Finnish government was represented by several ministers.

The exhibition was opened by Dr. Marcus Wallenberg after an address of welcome by the President of LMF, Mr. Ingmar Horelli. The Minister of Commerce and Industry, Mr. Grels Teir, presented the government's greetings, including an expression of gratitude for L M Ericsson's achievements on behalf of Finnish telephony.

The 124 million kronor contract between the Brazilian telephone operating company, Companhia Telefônica Brasileira (CTB), and Ericsson do Brasil (EDB) was signed on September 20. (From left) Sr. Geraldo Nóbrega, EDB, Mr. Gunnar Vikberg, President of EDB, General Landry Sales Gonçalves, Chairman of CTB, and Dr. Roberto Carlos Süssekind, CTB.

Brazilian Contract for 124 Million Kronor

The largest telephone operating company in Brazil, Companhia Telefônica Brasileira (CTB), signed in September 1968 a contract with L M Ericsson and its Brazilian subsidiary Ericsson do Brasil (EDB) for delivery of telecommunications equipment and installation work to a total of some 124 million kronor.

The contract with the Ericsson Group is a step in CTB's three-year plan for extension of the telephone service within the provinces of Rio de Janeiro, São Paulo, Minas Gerais and Esperito Santo. At the conclusion of this project CTB will possess three times as many trunk circuits as at present. The area concerned has a population of more than 20 million and is 22 times as large as Sweden.

The contract covers the delivery of advanced carrier equipment for trunk traffic and fully automatic exchange equipments.

About 80 % of the equipment will be delivered from EDB's factory at São José dos Campos. The remainder will be manufactured in Sweden.

Other major orders

KUWAIT

L M Ericsson has received its third order for telephone exchange equipments for Kuwait, comprising automatic equipment to a value of some 12 million kronor. Including contracts signed in 1966 and 1967 L M Ericsson will have delivered equipment for 59,000 lines, i.e. nearly three times as many lines as existed in the country before the first LME exchanges were cut over in December 1967. Kuwait will thereby attain the same number of telephones per 100 inhabitants as, for example, W. Germany today.

ETHIOPIA

The Director General of the Imperial Board of Telecommunications of Ethiopia, Ato Betru Admassie, has recently signed in Stockholm a contract for 7 million kronor with L M Ericsson covering, among other items, two new exchanges for altogether 16,000 lines for extension of the exchange network in Addis Ababa and surroundings.

The deal was preceded by an open invitation for tenders, in which Japanese, French and other firms participated.

L M Ericsson has thus further reinforced its position in Africa, where in the last year new orders have been received from Egypt, Tunisia, Malawi, Zambia and Kenya.

LEBANON

L M Ericsson has signed a contract with the Lebanese Telephone Administration to a value of some 5 million kronor for delivery of a new telephone exchange for central Beirut.

This is L M Ericsson's second contract in Lebanon this year.

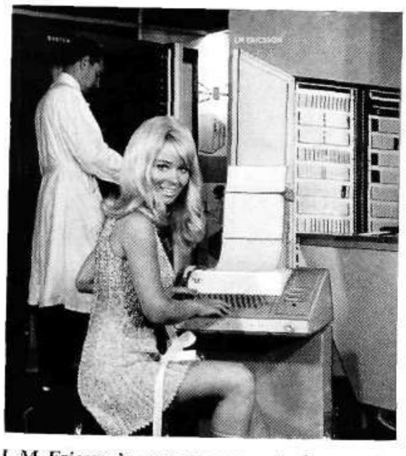
The Director General of the Imperial Board of Telecommunications of Ethiopia, Ato Betru Admassie, signs a 7 million kronor contract with L M Ericsson, here represented by Mr. Malte Patricks, Executive Vice President, and Mr. Hans Augustinson.

Dialog and Ericovox Approved in Austria

The two L M Ericsson telephones, Dialog and Ericovox, were approved in September by the Austrian authorities for connection to private exchange systems in the country.

The Ericsson-owned Centrum Electronics Ltd., London, announced in the second half of 1968 a competition entitled "The ideal secretary of the future". Among 6427 competitors the victor was Miss Jill Vowles, 18-year-old secretary from London. She was proclaimed Miss Centrum on November 18 at the finals at the Savoy Hotel, London. Among other members of the jury was Miss World 1968, Penelope Plummer (right).

L M Ericsson's annual report has again been acclaimed for its excellent accounting presentation and graphic design. In the assessment of annual reports made every year by the American Financial World Magazine, L M Ericsson's 1967 annual report was considered the second best in the class for non-American companies. The head of the Schools of Business at the University of New York, Mr. Joseph H. Taggart (right), is seen handing a diploma confirming the distinction to Mr. Sigge Malmström, Ericsson Centrum Inc., New York.



L M Ericsson's new process-control computer UAC 1600 was shown for the first time abroad at the INTERKAMA exhibition in Düsseldorf, W. Germany, on 9–15 October. Very great interest was shown also in UAC 1500 – a new electronic system for data collection.

The Chairman of the Board of L M Ericsson, Dr. Marcus Wallenberg, and President Björn Lundvall visited Ericsson do Brasil (EDB) in São José dos Campos on October 27. Dr. Wallenberg (centre) is seen examining the drawing of the buildings with (from right) Mr. Lundvall, Mr. Gunnar Vikberg, President of EDB, and Mr. Georg Dahlström, head of the factory.

*

Top-ranking executives of three large telephone companies in the USA visited L M Ericsson at Midsommarkransen at the end of October. The photograph is taken from the process room at the Tumba telephone exchange: (from right) Mr. P. A. Gorman, President of Western Electric Co., Mr. Björn Lundvall, President of L M Ericsson, Mr. K. G. McKay, Vice President of American Telephone and Telegraph Co., Mr. J. B. Fisk, President of Bell Telephone Laboratories, and Messrs. Fred Sundkvist and Christian Jacobæus, both of L M Ericsson.

A very large industrial exhibition was held during ten days in October in Bucharest, capital of Rumania. Nearly 50 Swedish firms took part. The Ericsson Group was represented by SRA (Svenska Radio AB).

L M Ericsson's activities were shown in illustrations with accompanying text, also telephones for various applications; but above all the visitors obtained a very good knowledge of SRA's most important products, e.g. mobile and marine, portable and stationary communication radio equipments, radio systems for forestry, hospitals etc.

Prince Henrik of Denmark presents the annual Danish industrial design prize to Mr. Paul Binzer, GNT-Automatic A/S. Mr. Raul Fjordboge (centre) of the Danish Industrial Design Association supervises the ceremony. The prize was received by GNT-Automatic for the tape and card punch model 34, which is one of the products L M Ericsson Data AB is to market in Sweden.]

DKB Sells GNT Products in Sweden

An agreement has been concluded under which L M Ericsson Data AB (DKB) will market the products of the Danish firm GNT-Automatic A/S in Sweden.

GNT-Automatic is an associated company of L M Ericsson, their products comprising chiefly data processing accessories and teleprinters.

The firm recently came into the limelight in Denmark through the award of the annual Danish industrial design prize – the ID Prize 1968 – for the tape and card punch model 34 with accessories.

This prize, which was instituted by the Danish Industrial Design Association, is awarded every year to one or more Danish companies which have brought out products of an exemplary utilitarian and aesthetic value from the design point of view. All branches of Danish industry can take part.

In its reasons for the award of the annual prize to GNT-Automatic the jury pointed out the compact construction of the punch, its rational form and effective operation.

John Mikael Sundberg In Memoriam

John Mikael Sundberg, until 1963 President of L M Ericsson's Argentinean cable works, Industrias Eléctricas de Quilmes, died on September 13 at his home in Alvor in southern Portugal, where he had lived since his retirement.

Sundberg was from Åland, the descendant of countless generations of farmers and seamen. After studying in Germany and many years of work in leading positions within the Finnish electrotechnical industry he came to L M Ericsson in 1947. Under his leadership the cable works at Quilmes was built and put into production and he led its operations with great skill for many years.

In remembering John Sundberg it is not in the first place the thoroughly knowledgeable specialist one thinks of, but a man with noble traits of character. He was among those who did not believe that the purpose of words was to conceal one's thoughts – he was the most straightforward and honourable person imaginable. Generous, helpful, and with a friendly wit, he was free from sarcasm and malice.

His many friends mourn a fearless man with a true kindliness of heart.

Sven Andrén

LME Group Share in Foreign Aluminium Works

An aluminium smelting works is to be built immediately above a source of natural gas on the island of Bahrein in the Persian Gulf. Swedish backers are ASEA and L M Ericsson.

The new smelting works, which is to be completed in 1971, will have a capacity of more than 57,000 tons. As Bahrein does not possess the raw material (aluminium oxide), this will be obtained principally from Australia and possibly from India as well. The entire production of aluminium will go to the companies forming the consortium.

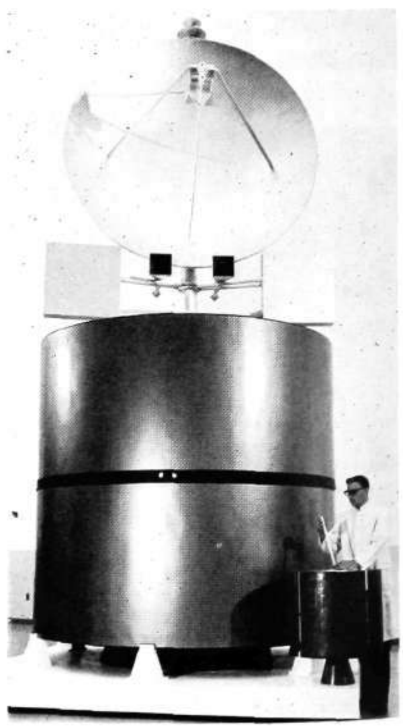
Through their participation the Swedish backers hope to be able to cover part of their very large requirement of aluminium at advantageous prices.

SRA Supplier for Large Satellite Project

SRA, Svenska Radio AB, one of the subsidiaries of the L M Ericsson Group, received in October an order for electronic equipment for control and supervision of three INTELSAT satellites and for ground equipment for final testing of the telecommunications systems of the satellites.

The American Hughes Aircraft Corporation is to be responsible for the project, which will cost a total of some 360 million kronor.

SRA is to deliver its equipment during 1969. The first satellite is planned to be in operation at the end of 1970.



Model of INTELSAT, i.e. the type concerned in the SRA order. The man on the right is holding his hand on an Early Bird model, the satellite which transmitted the first TV pictures.

Associated and co-operating enterprises and technical offices

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SIELTE, Soc. per Az. *I-00100 Roma*, C. P. 5100, tel: (06) 577 8041, tgm: sielte telex: 61225, "61225 SIELTE"

Netherlands

Ericsson Telefoonmaatschappij N.V. *Rijen (N.Br.)*, tel: 01692-3131, tgm: erictel, telex: 54114, "ERICTEL RIJEN"

Voorburg-Den Haag, P.O.B. 3060, tel: (070) 81 45 01, tgm: erictel-haag, telex: 31109, "ERICTEL DENHAAG"

Norway

A/S Elektrisk Bureau *Oslo 3*, P.B. 5055 Maj, tel: (02) 46 18 20, tgm: elektriken, telex: 1723, "ELEKTRIKEN O"

A/S Industrikontroll *Oslo 6*, Grenseveien 86/88,3. etg., tel: (02) 68 72 00, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.O.B. 500, tel: (02) 83 76 50, tgm: kabel, telex: 6549, "KABEL D"

A/S Telesystemer *Oslo 6*, Tvetenveien 32, Bryn, tel: (02) 46 18 20, tgm: telesystemer, telex: 6900, "ALARM OSLO"

Poland

Telefonaktiebolaget L M Ericsson, Technical Office, *Warszawa*, Ul Nowy Swiat 42, tel: 26 49 26, tgm: tellme, telex: 813710, "813710 TELLME PL"

Portugal

Sociedade Ericsson de Portugal Lda. *Lisboa 1*, Rua Filipe Folque 7, 1°, tel: 571 93, tgm: ericsson

Spain

Cia Española Ericsson, S. A. *Madrid 13*, Torre de Madrid, Plaza de España tel: (91) 241 14 00, tgm: ericsson, telex: 27369, "7369 ELEME E"

Sweden

Telefonaktiebolaget L M Ericsson, *126 11 Stockholm 32*, tel: 08/19 00 00, tgm: telefonbolaget, telex: 19910, "19910 ERICTEL S"

Bjurhagens Fabrikers AB, *212 15 Malmö*, Agnelundsvägen 14, Fack, tel: 040/93 47 70

Casa Konsult AB, *125 42 Älvsjö*, Huddingevägen 417—19, tel: 08/47 25 65, tgm: casakonsult

AB Ermi, *371 01 Karlskrona 1*, tel: 0455/230 10, tgm: ermibolag, telex: 4819, "ERMI KKR"

AB Rifa, *161 30 Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308, "ELRIFA STH"

Instruktionsteknik AB, *117 47 Stockholm 44*, tel: 08/68 08 70, tgm: instruktec

L M Ericsson Data AB, *171 88 Solna*, tel: 08/83 07 00, tgm: ericdata, telex: 1093, "ERICDATA STH"

L M Ericsson Telemateriel AB, *135 01 Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00 tgm: ellem, telex: 1275, "1275 TELERGA S"

Sieverts Kabelverk AB, *172 87 Sundbyberg*, tel: 08/28 28 60, tgm: sievertsfabrik, telex: 1676, "SIEVKAB STH"

Svenska Radioaktiebolaget, *102 20 Stockholm 12*, tel: 08/22 31 40, tgm: svenskradio, telex: 10094, "SVENSK-RADIO STH"

Switzerland

Ericsson A.G. *8032 Zurich*, Postfach, tel: (051) 325184, tgm: telericsson, telex: 52669, "TELERICSSON ZCH"

Turkey

Ericsson Türk Ticaret Ltd. Sirketi *Ankara*, Rumeli Han, Ziya Gökalp Cda., tel: 123170, tgm: ellem

Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 228102 tgm: ellemist

Izmir, Izmir Bürosu, Kisilkaya Han, Kat 3, No 13, Halit Ziya Bulvari, tel: 378 32, tgm: ellemir

West Germany

Deutsche Ericsson G.m.b.H. Telematerial, *4 Düsseldorf-Rath*, Postfach 136, tel: (0211) 63 30 31, tgm: erictel, telex: 8586871, "8586871 ERIC D"

Centrum Electronic G.m.b.H. *3 Hannover*, Postfach 1247, tel: (051) 631018, tgm: centronic, telex: 922913, "0922913 CELEC D"

• ASIA •

Hong Kong, Macao, Philippines, Taiwan

Telefonaktiebolaget L M Ericsson Technical office *Hong Kong*, P.O.B. 134781, tel: 23 10 91, tgm: elleme

India

Ericsson Telephone Sales Corporation AB *Calcutta 22*, P.O.B. 2324, tel: (033) 45 44 94, tgm: inderic

New Delhi 49, L25, South Extension Part II, tel: (011) 626505, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Ir. H. Djuanda 151, tel: (082) 8294, tgm: javeric

Djakarta, Djalan Gunung Sahari 26, tel: (07) 48531, tgm: javeric

Iraq

Telefonaktiebolaget L M Ericsson, Technical office *Baghdad*, P.O.B. 493, tel: 914 54, tgm: ellemco

Kuwait

Telefonaktiebolaget L M Ericsson, Technical office, *Kuwait, State of Kuwait*, P.O.B. 5979, tel: 26 855, tgm: erictel

Lebanon

Telefonaktiebolaget L M Ericsson, Technical office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 252627, tgm: ellem, telex: 876, "ELLEM BERYT"

Malaysia

Ericsson Talipon SDN BHD, *Petaling Jaya*, P.O.B. No 9, tel: Kuala Lumpur (03) 56 15 23, tgm: kuleric Kuala Lumpur, telex: 265 "ERICMAL KL"

Pakistan

L M Ericsson Telephone Company, Technical Office, *Karachi*, P.O.B. 7398, tel: (90) 56112, tgm: ericsson

Singapore

Ericsson Telephone Co. Private Ltd. *Singapore 1*, P.O.B. 3079, tel: 98 11 55, tgm: sineric

Thailand

Ericsson Telephone Corp. Far East AB *Bangkok*, P.O.B. 824, tel: (02) 555 11—12, tgm: ericsson, telex: 2274 "THAIERIC"

• AFRICA •

Egypt (UAR)

Telefonaktiebolaget L M Ericsson, Technical office Egypt Branch *Cairo* P.O.B. 2084, tel: (02) 46581, tgm: elleme

Ethiopia, Sudan

Telefonaktiebolaget L M Ericsson Technical office, *Addis Ababa*, P.O.B. 3366, tel: (01) 492 60, tgm: ericsson, telex: 210 90 "MOSFIRM ADDIS"

Kenya, Tanzania, Uganda

Telefonaktiebolaget L M Ericsson, Technical office, *Nairobi*, P.O.B. 9063, tel: (02) 271 06, tgm: ellem

Libya

LM Ericsson Technical Office, *Tripoli*, P.O.B 3002, tgm: ericsson

Malawi

Ericsson Telephone Sales Corporation AB, *Blantyre*, P.O.B. 431

Morocco

Société Marocaine des Téléphones Ericsson *Casablanca*, 87, Rue Karatchi tel: 788 75, tgm: ericsson

Rhodesia and Botswana

Ericsson Telephone Sales Corporation AB, *Salisbury, Rhodesia*, P.O.B. 2891, tel: (10) 25 737, tgm: ericofon

South Africa and Southwest Africa

L M Ericsson Telephone Co. (Pty.) Ltd. *Johannesburg*, P.O.B. 7419, tel: 836 4091

Tunisia

Telefonaktiebolaget L M Ericsson, Technical office, *Tunis*, Boîte Postale 780, tel: (01) 240520, tgm: ericsson, telex: 695, "ERICSSON TUNIS".

Zambia

Ericsson Telephone Sales Corporation AB *Ndola*, P.O.B. 2256, tel: (143) 3885, tgm: ericofon

Lusaka, P.O.B. 2762, tel: (146) 772 90, tgm: ericofon

• AMERICA •

Argentine

Cía Ericsson S.A.C.I. *Buenos Aires* Casilla de Correo 3550, tel: 332071, tgm: ericsson, telex: 0122196, "CATEL BA"

Cía Argentina de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel, telex: 0122196, "CATEL BA"

Cía Entrerriana de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 332076, tgm: catel, telex: 0122196, "CATEL BA"

Industrias Eléctricas de Quilmes S.A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenos-aires, telex: 0122196, "CATEL BA"

Brazil

Ericsson do Brasil Comércio e Indústria S.A. *Rio de Janeiro* C.P. 3601-ZC-00, tel: 43-0990, tgm: ericsson, telex: 731839, "ERICSSON RIO"

Fios e Cabos Plasticos do Brasil S.A. (FICAP), *Rio de Janeiro*, caixa postal: 1828, tel: 290185, tgm: ficap, telex: 731563, "PLASTIVINE RIO"

Canada

L M Ericsson Ltd. *Montreal 9. P.Q.*, 2300 Laurentian Boulevard City of St. Laurent, tel: (514) 331-3310, tgm: caneric, telex: (TWX) 610-421-3311, "CANERIC MTL"

Ericsson Centrum Ltd. *Montreal*, 1203, IBM Building, 5, Place Ville Marie

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Telefonaktiebolaget L M Ericsson, oficina Tecnica de Centroamérica y Panama, *San Salvador*, Apartado 188, tel: 21 76 40, tgm: ericsson

Chile

Cía Ericsson de Chile S.A. *Santiago*, Casilla 10143, tel: (04) 82555, tgm: ericsson, telex: SGO 389, "ERICHILE SGO389"

Colombia

Cía Ericsson Ltda, *Bogotá*, Apartado Aéreo 4052, tel: (92) 411100, tgm: ericsson, telex: 044507, "ERICSSON BOG"

Fabricas Colombianas de Materiales Eléctricos Fácomec S.A. *Cali*, Apartado Aéreo 4534, tel: 8716, tgm: facomec, telex: 55673, "FACOMEC CLO"

Costa Rica

Telefonaktiebolaget L M Ericsson, Technical office *San José*, Apartado L. M. E., tel: 21 14 66, tgm: ericsson

Ecuador

Teléfonos Ericsson C.A. *Quito*, Casilla 2138, tel: 21 61 00, tgm: ericsson

Guayaquil, Casilla 376, tel: 52 69 00, tgm: ericsson

Cont. on next page

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Teléfonos Ericsson S.A. *Mexico D.F.*, Apartado 9958, tel: (25) 464640, tgm: coeric, telex: 0177485, "ERICSSON MEX"

Latinoamericana de Cables S.A. de C.V. *Mexico 12 D.F.*, Apartado 25737, tel: (25) 49 36 50, tgm: latincasa

Teleindustria, S.A. de C.V. *Mexico I, D.F.* apartado 1062, tel: (25) 46 46 40, tgm: ericsson, telex: 0177485, "ERICSSON MEX"

Telemontaje, S.A. de C.V. *Mexico 1, D.F.*, Apartado Postal 1062, tel: 46 78 11, tgm: ericssonmexicodf, telex: 0177485, "ERICSSON MEX"

Peru

Cia Ericsson S.A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson, telex: 3540202, "ERICSSON 3540202"

Soc. Telefonica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 6060, tgm: telefonica

El Salvador

Telefonaktiebolaget L M Ericsson Technical office *San Salvador*, Apartado 188, tel: 21-7640, tgm: ericsson

Uruguay

Cia Ericsson S.A. *Montevideo*, Casilla de Correo 575, tel: 92611, tgm: ericsson

USA

The Ericsson Corporation *New York, N.Y. 10017*, 100 Park Avenue, tel: (212)685-4030, tgm: erictel, telex: 620484, "ERICTEC 620484"

L M Ericsson Centrum Inc. *New York, N.Y. 10016*, 16, East 40th Street, tel: (212)679-1000, tgm: erictel, telex: 620149

Venezuela

Cia Anónima Ericsson *Caracas*, Apartado 3548, tel: (02) 34 46 61/2..5, tgm: ericsson, telex: "734, 734 ERICSSON VE"

Alambres y Cables Venezolanos C.A. (ALCAVE) *Caracas*, Apartado del Este 11257, tel: (02) 33 97 91, tgm: alcave, telex: 845, "ALCAVE VE"

• AUSTRALIA & OCEANIA •

Australia

L M Ericsson Pty. Ltd. *Broadmeadows, Victoria 3047*, P.O.B. 41, tel: (03) 309 22 44, tgm: ericmel, telex: AA 30555

Rushcutters Bay N.S.W. 2011, 134 Barcom Avenue, tel: (02) 31 09 41, tgm: ericsyd, telex: AA 21358 "ERIC-SYD"

Port Moresby, Territory of Papua and New Guinea, P.O.B. 1367, Boroko, tel: 56 965, tgm: ericpor

Teleric Pty. Ltd *Broadmeadows, Victoria 3047*, P.O.B. 41, tel: (03) 309 2244, tgm: teleric, telex: AA 30555

Rushcutters Bay N.S.W. 2011, 134 Bacrom Avenue, tel: (02) 31 09 41, tgm: teleric, telex: AA 21358, "ERIC-SYD"

Conqueror Cables Pty. Limited, *Dee Why, N.S.W. 2099*, P.O.B. 69, tel: 98 03 64, tgm: concab sydney

A.E.E. Capacitors Pty. Ltd. *Preston, Victoria 3072*, 202 Bell Street, P.O.B. 95, tel (03) 480 12 11, tgm: engiquip melbourne

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• EUROPE •

Austria

Telecom Handelsgesellschaft m.b.H., *1142 Wien*, Schanzstrasse 33, tel: 92 26 21, tgm: teleric, telex: 11638, "11638 TELCOM A"

Belgium

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Greece

Angelos Cotzias *Athens*, 18, Odas Omirou, tel. 626-031, tgm: cotziasan, telex: 252, "COTZIASAN ATHEN"

Iceland

Johan Rönning H/F *Reykjavik*, P.O.B. 883, tel: 10632, tgm: rönning

Spain

TRANSA Transacciones Canarias S.A., *Las Palmas de Gran Canarias*, Tomas Morales 38, tel: 21 85 08, tgm: transa, telex: 824, "MAVAC LPE"

Yugoslavia

Merkantile Inozemna Zastupstva *Zagreb* pošt pretinac 23, tel: 36941, tgm: merkantile, telex: 21139, "21139 YU MERTIL"

• ASIA •

Abu Dhabi

Mohammed Bin Masaood & Sons, *Abu Dhabi, Trucial States*, P.O.B. 332, tel: 2367, tgm: almasaood

Burma

Myanma Export Import Corp., Agency Div. *Rangoon*, P.O.B. 404, tel: 146 18, tgm: myanimport

Cambodia

Comin Khmere S.A. *Phnom-Penh*, P.O.B. 625, tel: 23334, tgm: engineer

Cyprus

Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

S.A. Petrides & Sons Ltd. *Nicosia*, P.O.B. 1122, tel. 2788, tgm: armature

Hong Kong and Macao

Swedish Trading Co. Ltd. *Hong Kong*, P.O.B. 108, tel: 23 10 91, tgm: swedetrade

Iran

Irano Swedish Company AB, *Teheran* Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswede

Iraq

Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 492, tel: 87031, tgm: alhamra

Jordan

The Arab Trading & Development Co. Ltd. *Amman.*, P.O.B. 6141, tel: 25981, tgm: aradeve

Kuwait

Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat telex: 048, "BEHBEHANI KUWAIT"

Lebanon

Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 231624, tgm: skefko

Pakistan

TELEC Electronics & Machinery Ltd. *Karachi 3*, 415, Mahboob Chambers, Victoria Road, tel: (90) 52648, tgm: elco

Philippines

U.S.I. Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: PN 3550, "USIPHIL PN 3550"

Saudi Arabia

Engineering Projects & Products Co. *Riyadh*, P.O.B. 987, tel: Murraba 264, tgm: eppcol

Syria

Constantin Georgiades, *Damas*, P.O. B. 2398, tel: 266 73, tgm: georgiades

Dubai

DOLPHIN Trading & Contracting Establishment, *Dubai, Trucial States*, P.O.B. 1566, tel: 22645, tgm: dolphin

Vietnam

Vo Tuyen Dien-Thoai Vietnam, *Saigon, Republic of Vietnam*, P.O.B. 1049, tel: 22660, tgm: telerad

International Business Representative, *Saigon, Republic of Vietnam*, 26—28, Hai Ba Trung Street, tel: 22660, tgm: ibur

• AFRICA •

Congo

I.P.T.C. (Congo) Ltd. *Kinshasa 1*, P.O.B. 8922, tel: 5345, tgm: induexpan, telex: 327, "IPTC KIN"

Ethiopia

Mosvold Company (Ethiopia) Ltd. *Addis Ababa*, P.O.B. 1371, tel: 14567, tgm: mosvold, telex: 21090 "MOSFIRM ADDIS ABABA"

Ghana

R.T. Briscoe Ltd. *Accra*, P.O.B. 1635, tel: 669 03, tgm: Briscoe, telex: 295, "BRISCOE ACCRA"

Kenya, Tanzania, Uganda

Transcandia Ltd. Telecommunications Division *Nairobi, Kenya*, P.O.B. 5933, tel: 27103, tgm: transcanda

Liberia

Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Streets, tel: 222 22, tgm: radiolibe

Libya

ADECO African Development & Engineering Co *Tripoli*, P.O.B. 2390, tel: 33906, tgm: adeco

Mozambique

J. Martins Marques & Ca. Lda. *Lourenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

Sudan

Contomichalos, Sons & Co. Ltd. Engineering & Agencies Dept., *Khartoum*, P.O.B. 866, tel: 77 695, tgm: suconta, telex: 251, "CONTOLOS"

South Africa, South-West Africa

Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

Tunisia

Ateliers Mécaniques du SAHEL, Sousse, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

• AMERICA •

Bahama Islands

Anglo American Electrical Company Ltd. *Freeport, Grand Bahama*, P.O.B. 104

Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 22 55 11, tgm: troco

Dominican Republic

Garcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3445, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 21 79 40, tgm: nilspira

Guiana

General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwiks

Honduras

Quinchón Leon y Cia *Tegucigalpa*, Apartado 85, tel: 2-5171, tgm: quinchon

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 24077, tgm: morrispark

Netherlands Antilles

S.E.L. Maduro & Sons, Inc. *Willemstad, Curaçao* P.O.B. 304, tel: 11200, tgm: madurosons

Nicaragua

Sonitel Centroamerica S.A. *Managua*, Apartado 1271, tel: 4476, tgm: sonitel

Panama

Sonitel, S.A. *Panama, R.P.*, Apartado 4349, tel: 25-3640, tgm: sonitel, telex: 134, "PA 134 SONITEL"

Paraguay

S.A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

El Salvador

Dada-Dada & Co. *San Salvador* Apartado 274, tel: 217940, tgm: dada

Trinidad, W.I.

Leon J. Aché Ltd. *Port-of-Spain*, 100 Frederick Street, tel: 32357, tgm: achegram

• AUSTRALIA & OCEANIA •

New Zealand

ASEA Electric (NZ) Ltd. *Wellington C. 1.*, P.O.B. 3239, tel: 70-614 tgm: asea, telex: 3431, "ASEAWELL NZ 3431"

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